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Voyager 1 Encounter With Jupiter



National Aeronautics and
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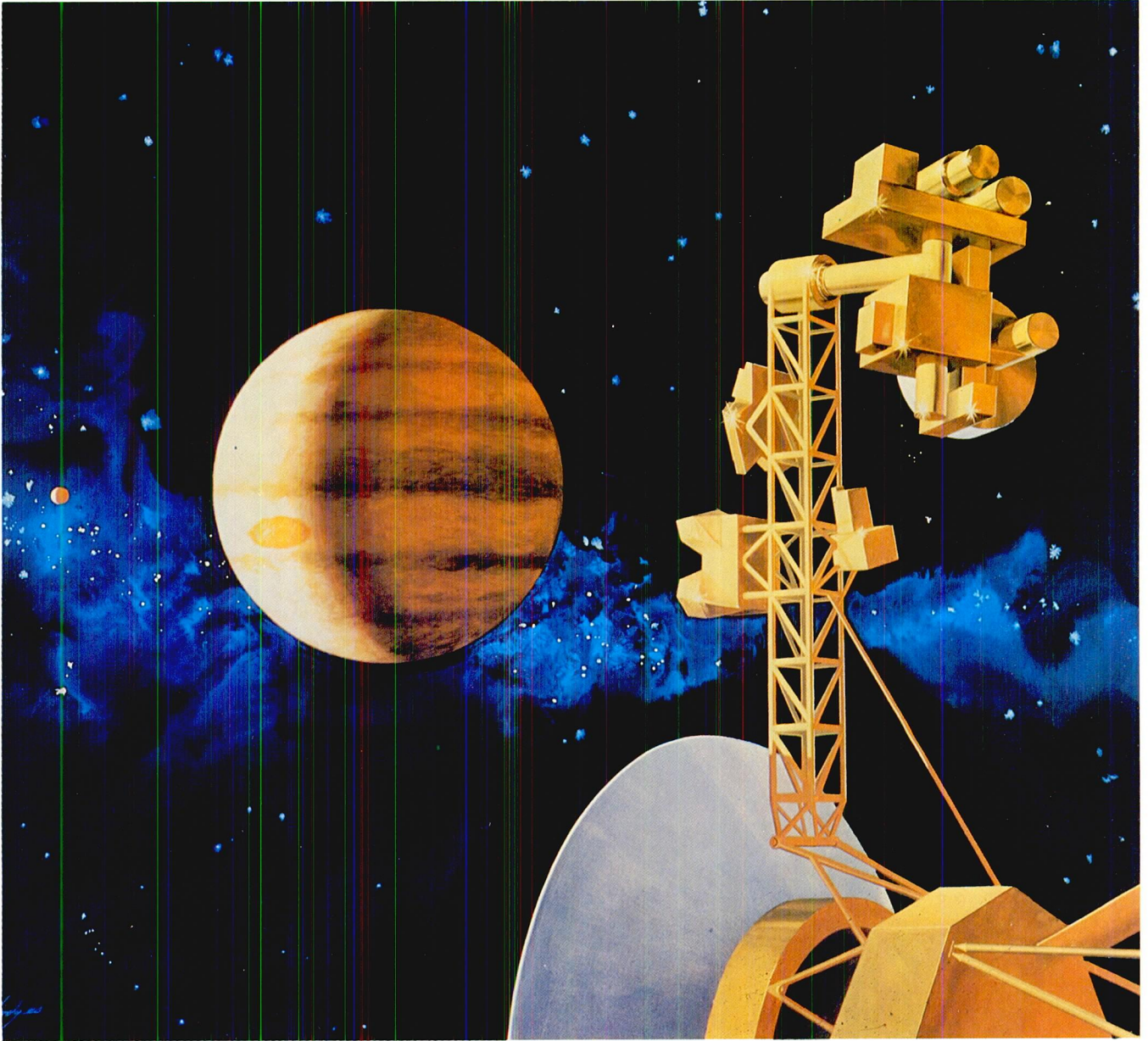
Voyager 1 Encounter With Jupiter

March 1979



National Aeronautics and
Space Administration

N80-17003#



The Voyager Project

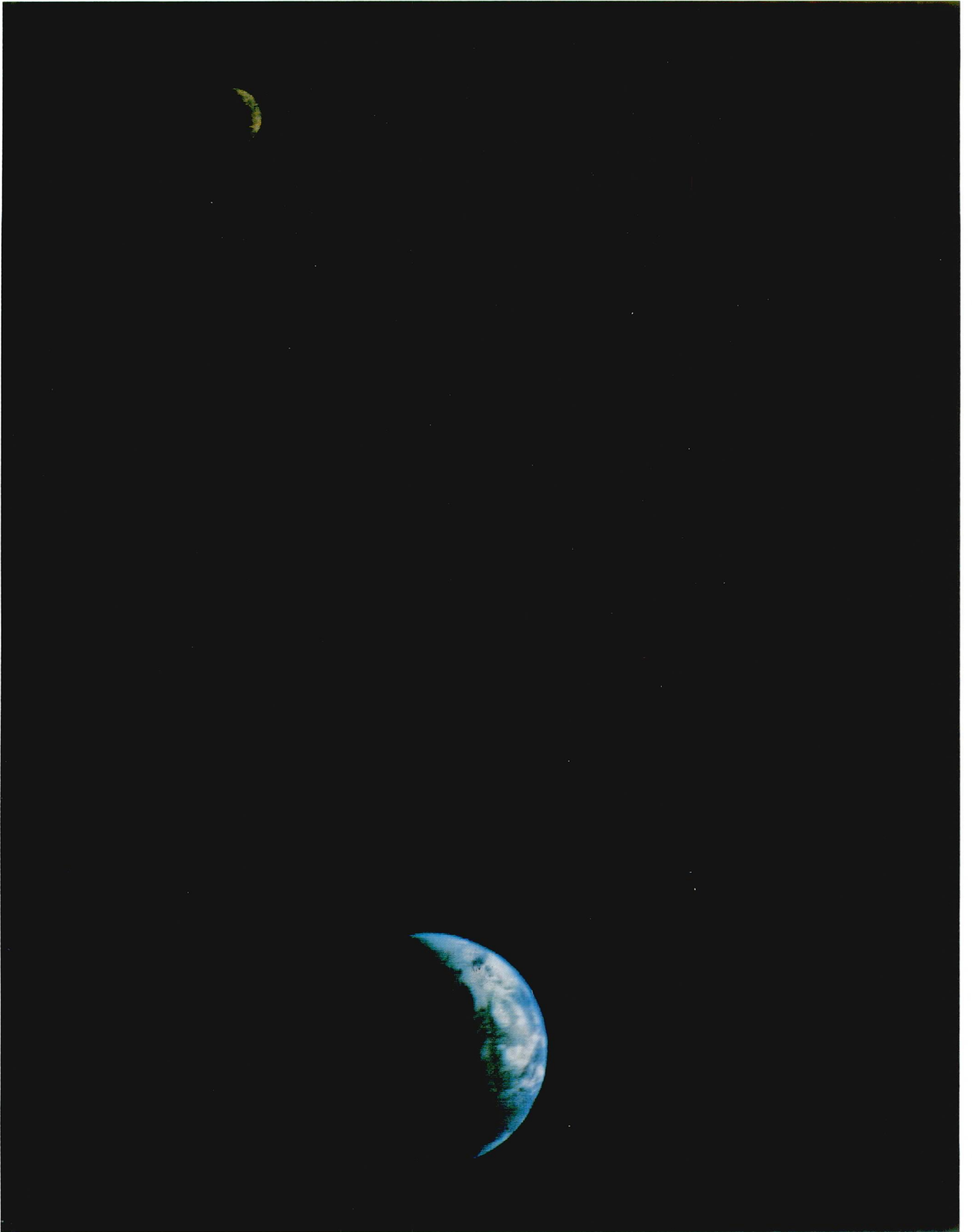
On September 5, 1977, the Voyager 1 spacecraft was launched on a 38-month mission to explore the planets Jupiter and Saturn. The pictures in this book are a sampling of the nearly 19,000 photographs returned by the spacecraft at the midpoint of its journey, including its closest approach to Jupiter and the Galilean satellites on March 5, 1979

The National Aeronautics and Space Administration was authorized by the Congress in 1972 to implement the Voyager Project to fly two automated, instrumented spacecraft to the outer planets Jupiter, Saturn, and possibly Uranus. Over 10,000 Americans participated in the design, construction, and testing of Voyager 1 and its sister-ship, Voyager 2, during the six-year period preceding launch. The two 808 kg (1782 lb), nuclear-fueled spacecraft are designed to conduct sophisticated programs of scientific observations as they travel through the remote and sometimes hostile reaches of our solar system. Spanning 17 meters (57 feet) and operating on a mere 400 watts of power, Voyager 1 is currently communicating from a distance of over 500 million miles as it heads for Saturn at a velocity of 20 times greater than that of a high-speed bullet. Voyager 2 will encounter Jupiter in July 1979.

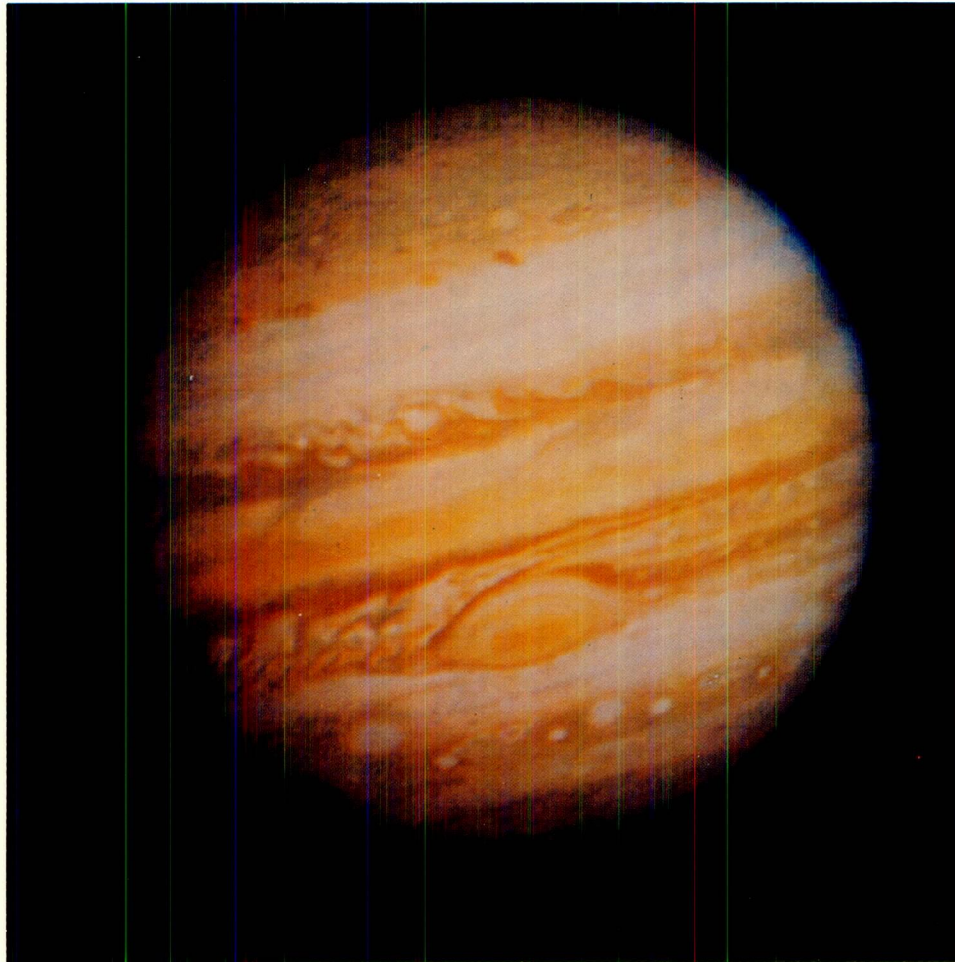
The recent windfall of information, including these photographs, has dramatically revised man's understanding of Jupiter and its moons, which together form a "solar" system unto themselves. Jupiter's atmosphere is a study in motion, with opposing currents of air passing among a myriad of "storms" — rotational patterns which range from short-lived eddies to decades- and centuries-old spots as large as Earth. In addition, bright aurorae and lightning are apparently commonplace on this giant planet. Finally, a thin ring has been discovered encircling Jupiter.

The innermost satellite, Amalthea, is an elongated object whose long axis is ever-pointed at the planet. Io is a lunar-sized body whose surface is the most active yet observed in our solar system. It appears that volcanic eruptions are continually covering Io's surface with dust and lava from the satellite's interior and perhaps provide a constant supply of material for a Jupiter-encircling torus of sulfur. Europa, viewed from afar, presents tantalizing linear features on its surface, bait to tempt Voyager 2 toward a closer Europa flyby. Ganymede is a satellite whose surface yields readily to pressure, suggesting an icy composition overlying a liquid interior. Large-scale relief is apparently absent on Ganymede, and widespread fracturing suggests that the surface has bent and buckled to a large degree. Callisto reveals a history of early and intense bombardment. Frozen in its surface is a record of millions of impacts, apparently unchanged by subsequent volcanic or crustal activity.

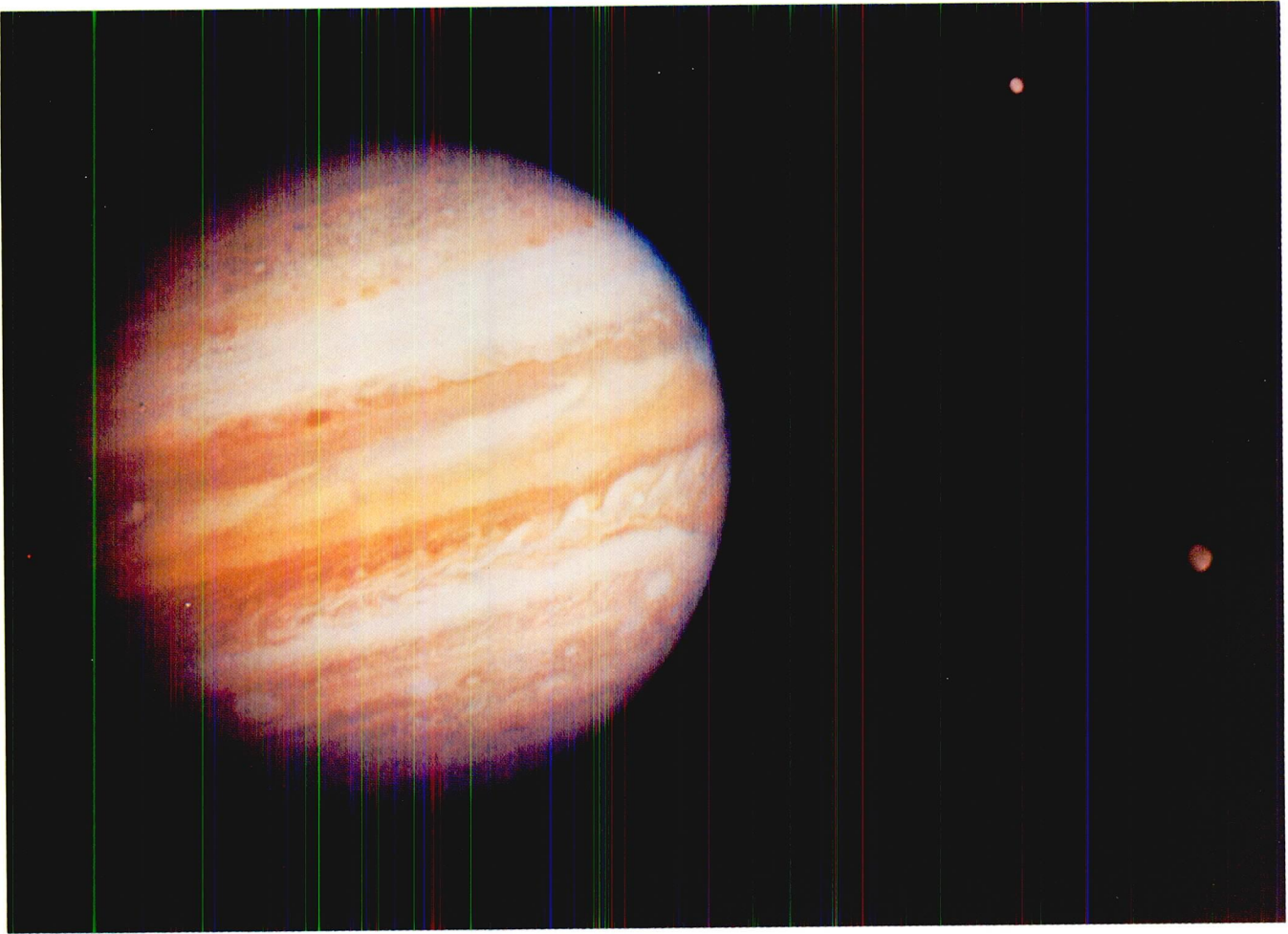
The saga of Voyager will continue as both spacecraft journey through the outer solar system.



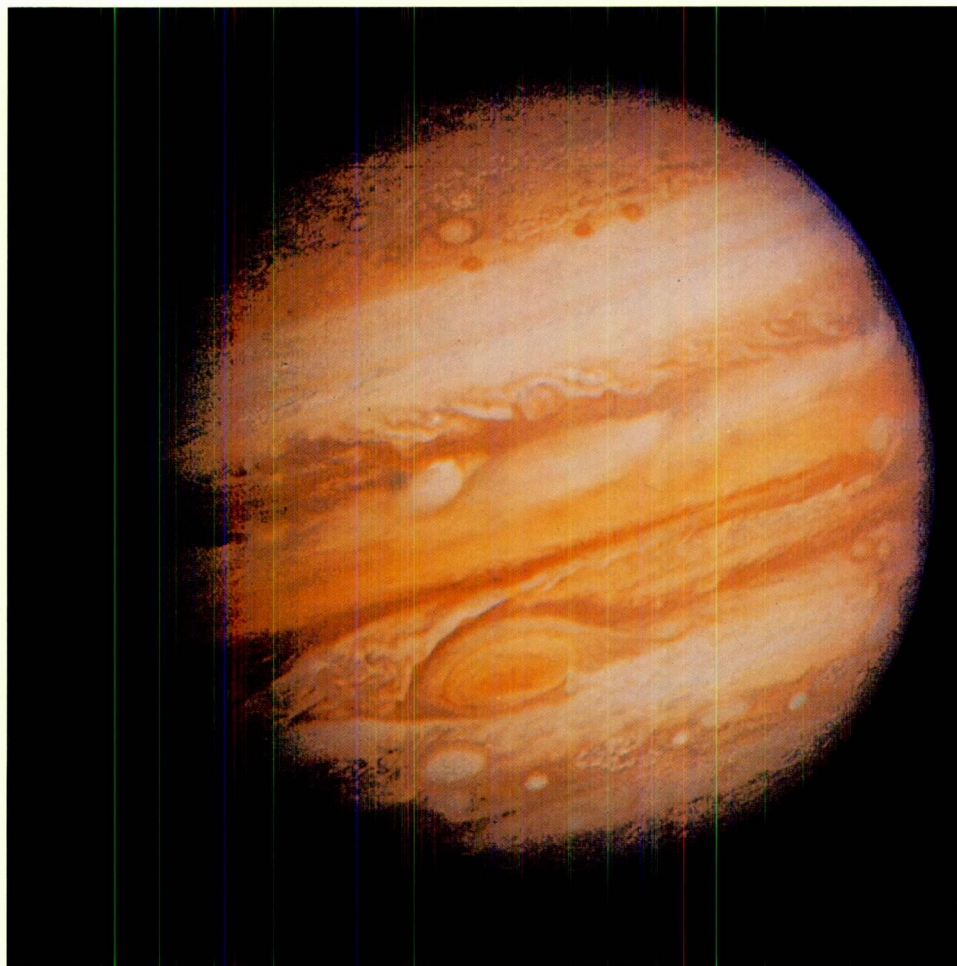
This picture of a crescent-shaped Earth and Moon — the first of its kind ever taken — was recorded on September 18, 1977, by Voyager 1 when it was 11.66 million kilometers (7.25 million miles) from Earth. The Moon is at the top of the picture. The lighted portion of Earth shows eastern Asia, the western Pacific Ocean, and part of the Arctic. Voyager 1 was directly above Mt. Everest (on the night side of the planet at 25° north latitude) when the picture was taken. Because the Earth is many times brighter, the Moon was computer-enhanced and artificially brightened by a factor of three relative to Earth.



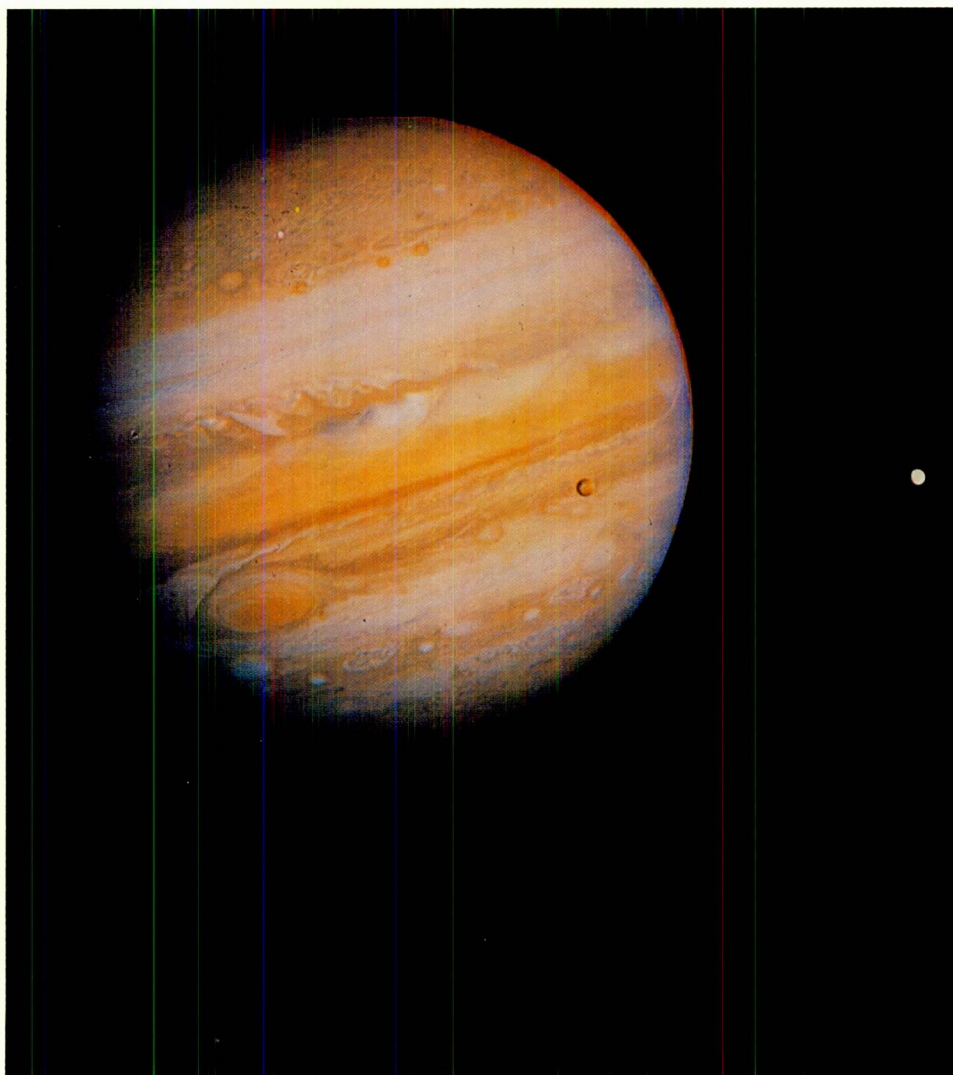
This photo of Jupiter, taken on January 9, 1979, through three filters, by Voyager 1 television cameras, is dominated by the Great Red Spot (lower center). Although the spacecraft is still 54 million kilometers (34 million miles) from its closest approach, Voyager's cameras already reveal details within the spot that are not visible from Earth. An atmospheric system larger than Earth and more than 300 years old, the Great Red Spot remains a mystery, although Voyager's instruments and cameras have returned invaluable scientific data. Swirling, storm-like features possibly associated with wind shear can be seen both to the left and above the Great Red Spot. Analysis of motions of the features will lead to a better understanding of weather in Jupiter's atmosphere.



Voyager 1's cameras captured two of Jupiter's moons, Ganymede (right center) and Europa (top right), in this picture taken during the morning of January 17, 1979, from a distance of 47 million kilometers (29 million miles). Despite the small images of the moons, this and other photos were beginning to show details on the satellites not seen before in photos taken from Earth. Europa, an unusually bright satellite a little smaller than the Moon, is revealed to have a dark equatorial band. Although scientists believe Europa to be a rocky satellite, its surface appears to be covered with a layer of ice or frost of undetermined thickness. This photo shows only the darker side of Ganymede, which is larger than the planet Mercury. The hidden half, as seen in other photos of Ganymede, marked by a large bright region, is believed to be composed of a mixture of rock and water ice with a surface of ice or frost and a scattering of darker soil. Scientists have been observing rapid changes in Jupiter's atmosphere — some occurring within 20 hours (two Jovian days). An example is changes shown in the long series of wave-like patterns trailing Jupiter's Great Red Spot. The bright zone stretching across the northern hemisphere may be clouds of frozen ammonia similar to cirrus clouds of water ice in Earth's atmosphere.



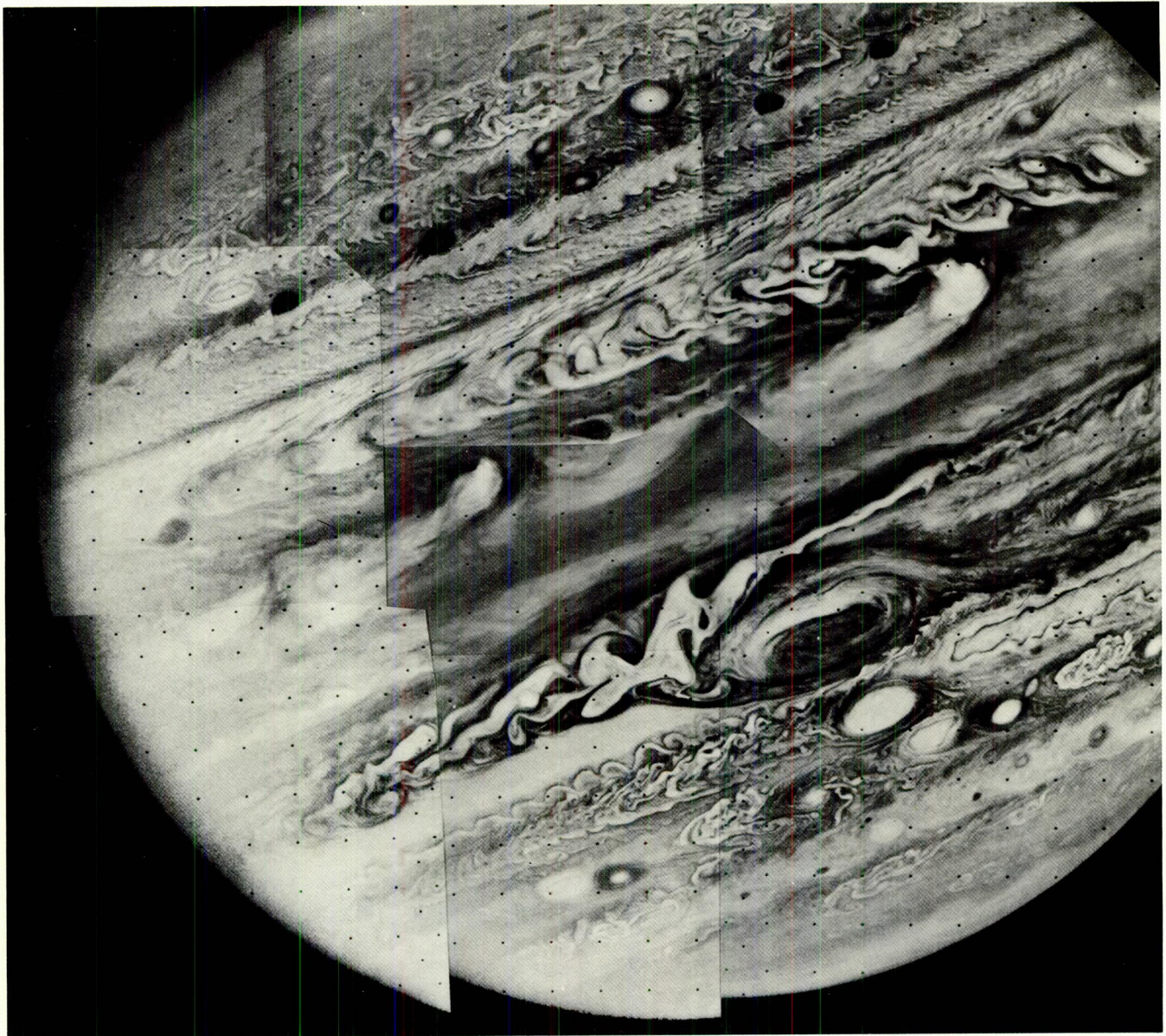
This photo of Jupiter taken by Voyager 1 on February 1, 1979, at a range of 32.7 million kilometers (20 million miles), shows different colors in clouds around the Great Red Spot, which imply that the clouds swirl around the spot at varying altitudes. Apparently regular spacing also is seen between the small white spots in the southern hemisphere and similar positioning of dark spots in the northern hemisphere. A major activity will be to understand the form and structure of the spots and how they may relate to interactions between the atmospheric composition and its motions. When scientists compare this image with the 6000 others already taken, they see many changes. The bright cloud in the equatorial region north of the Great Red Spot, for example, appears to be where bright clouds originate, then stream westward. On the other hand, the bright ovals south of the Great Red Spot were seen to form about 40 years ago and have remained much the same ever since. The Great Red Spot itself has been observed for hundreds of years, though never in the detail seen here. Objects as small as 600 kilometers (375 miles) across can be seen in this image. This photo was produced from three black-and-white images taken through blue, green, and orange filters.



Jupiter, its Great Red Spot, and three of its four largest satellites are visible in this photo taken on February 5, 1979, at a distance of 28.4 million kilometers (17.5 million miles). The innermost large satellite Io can be seen against Jupiter's disk. Io is distinguished by its bright, brown-yellow surface. To the right of Jupiter is the satellite Europa, also very bright but with fainter surface markings. The darkest satellite, Callisto (still nearly twice as bright as Earth's Moon), is barely visible at the bottom left of the picture. Callisto shows a bright patch in its northern hemisphere. All three satellites orbit Jupiter in the equatorial plane, and appear in their present position because Voyager is above the plane. All three satellites always show the same face to Jupiter — just as Earth's Moon always shows us the same face. In this photo, the sides of the satellites that always face away from the planet are seen. Jupiter's colorfully banded atmosphere displays complex patterns highlighted by the Great Red Spot, a large, circulating atmospheric disturbance. This photo was assembled from three black and white negatives.



Voyager 1 took this dramatic photo of Jupiter and two of its satellites (Io, left, and Europa, right) on February 13, 1979. Io is about 350,000 kilometers (220,000 miles) above Jupiter's Great Red Spot; Europa is about 600,000 kilometers (375,000 miles) above Jupiter's clouds. Although both satellites have about the same brightness, Io's color is very different from Europa's. Preliminary evidence suggests color variations within and between the polar regions. Io's surface composition is unknown, but scientists believe it may be a mixture of salts and sulfur. Europa is less strongly colored. Markings on Europa are less evident than on the other satellites, although this picture shows darker regions toward the trailing half of the visible disk. Jupiter is about 20 million kilometers (12.4 million miles) from the spacecraft. At this resolution (about 400 kilometers or 250 miles), there is evidence of circular motion in Jupiter's atmosphere. While the dominant large-scale motions are west to east, small-scale movement includes eddy-like circulation within and between the bands. This photo was produced from three black-and-white images taken through blue, green, and orange filters.



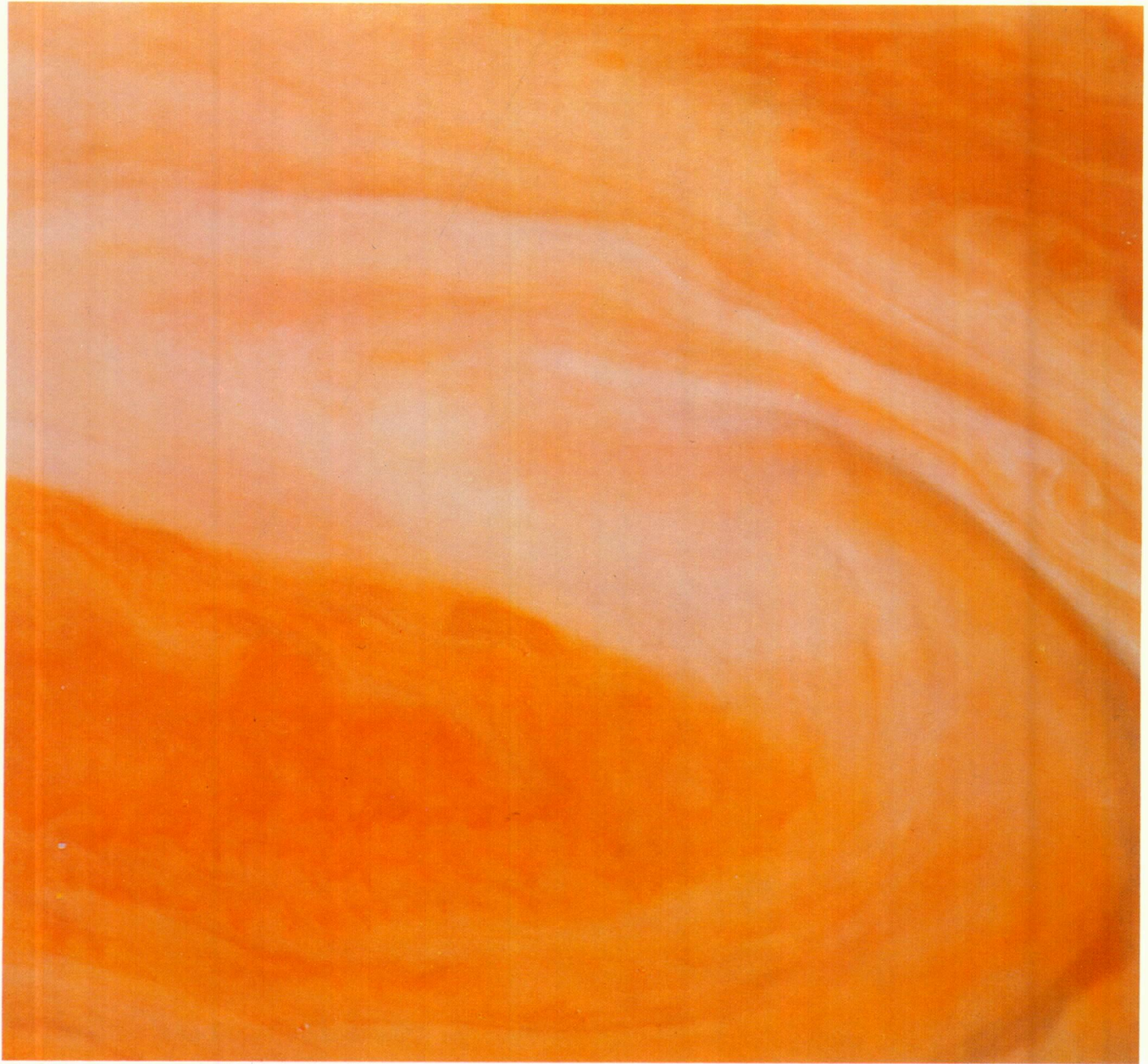
This mosaic of Jupiter was assembled from nine individual photos taken through a violet filter by Voyager 1 on February 26, 1979, at a distance of 7.8 million kilometers (4.7 million miles) from Jupiter. Distortion of the mosaic, especially noticeable where portions of the limb or edge of the planet have been fitted together, is caused by rotation of Jupiter during the 96-second intervals between individual frames. The large atmospheric feature just below and to right of center is the Great Red Spot. The complex structure of the cloud formations seen over the entire planet gives some hint of the equally complex motions in the Voyager time-lapse photography. The smallest atmospheric features seen in this view are approximately 140 kilometers (85 miles) across.



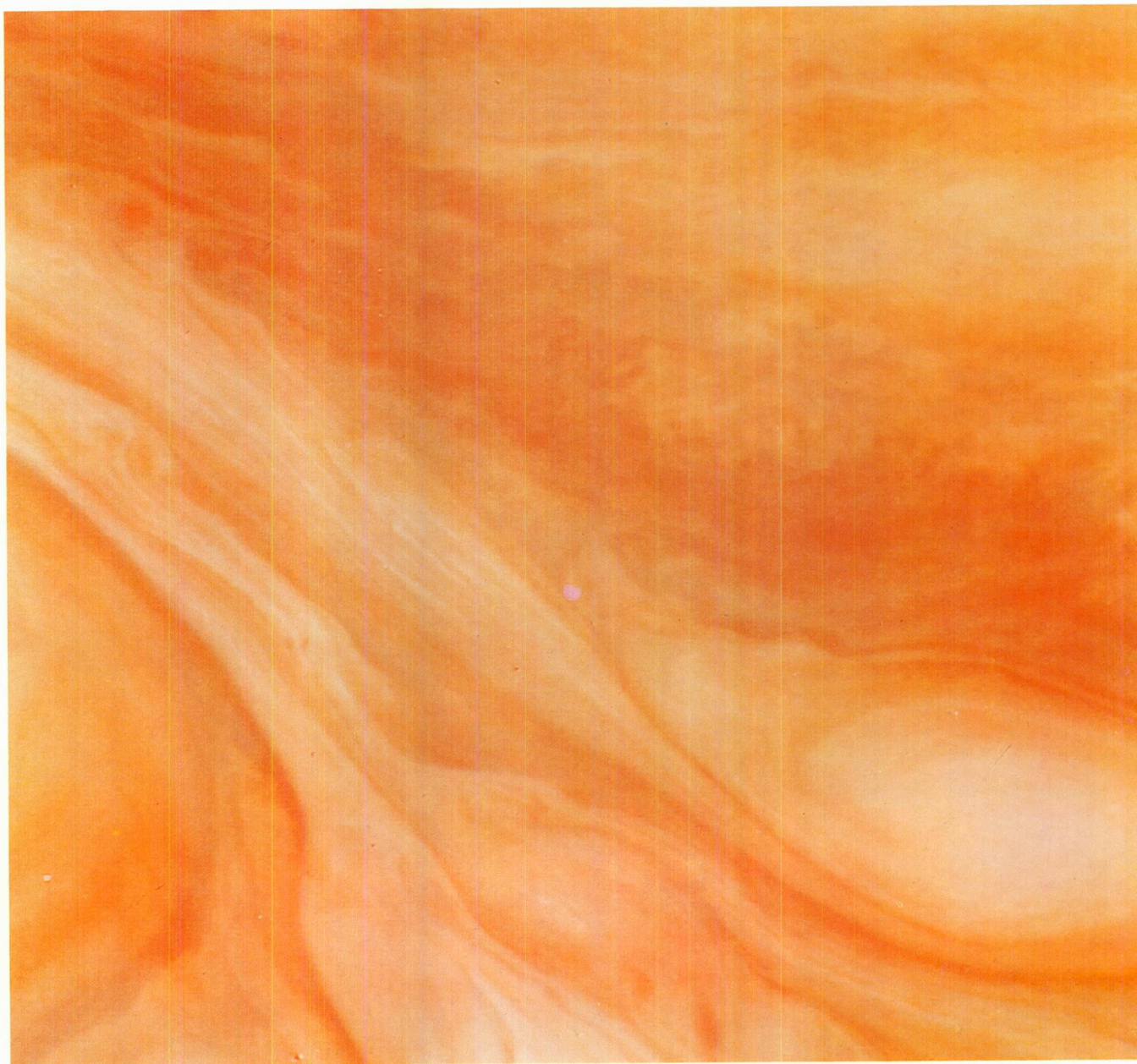
This dramatic view of Jupiter's Great Red Spot and its surroundings was obtained by Voyager 1 on February 25, 1979, when the spacecraft was 9.2 million kilometers (5.7 million miles) from Jupiter. Cloud details as small as 160 kilometers (100 miles) across can be seen. The colorful, wavy cloud pattern to the left of the Red Spot is a region of extraordinarily complex and variable wave motion. This color photo was assembled from three black-and-white frames.



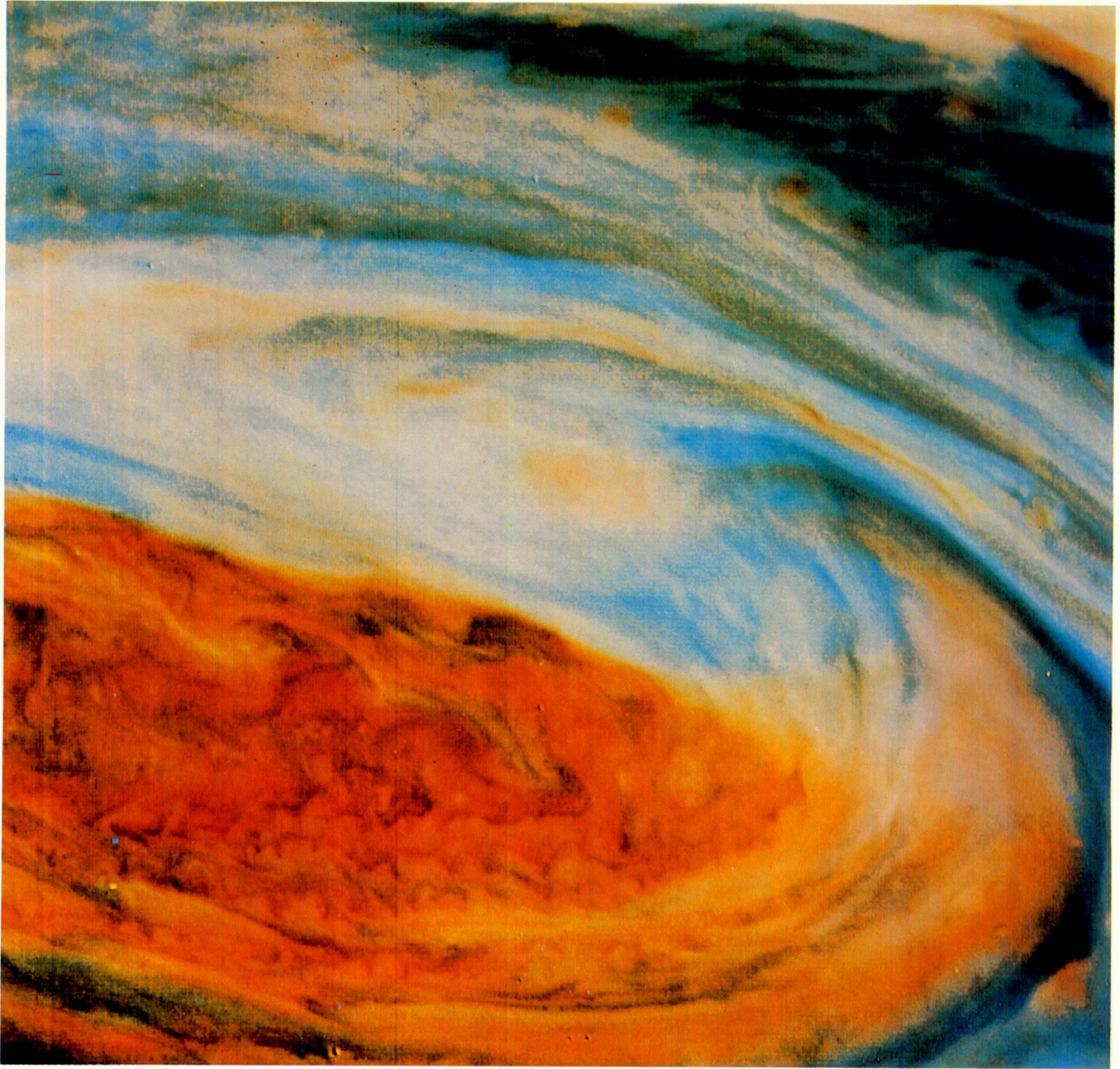
This photo of Jupiter was taken by Voyager 1 on March 1, 1979, at a distance of 5 million kilometers (3 million miles). The photo shows Jupiter's Great Red Spot (upper right) and the turbulent region immediately to the west. At the middle right of the frame is one of several white ovals seen on Jupiter from Earth. The detail in every structure here is far better than has ever been seen from any Earth-based telescopic observations. The smallest details that can be seen in this photo are about 95 kilometers (55 miles) across.



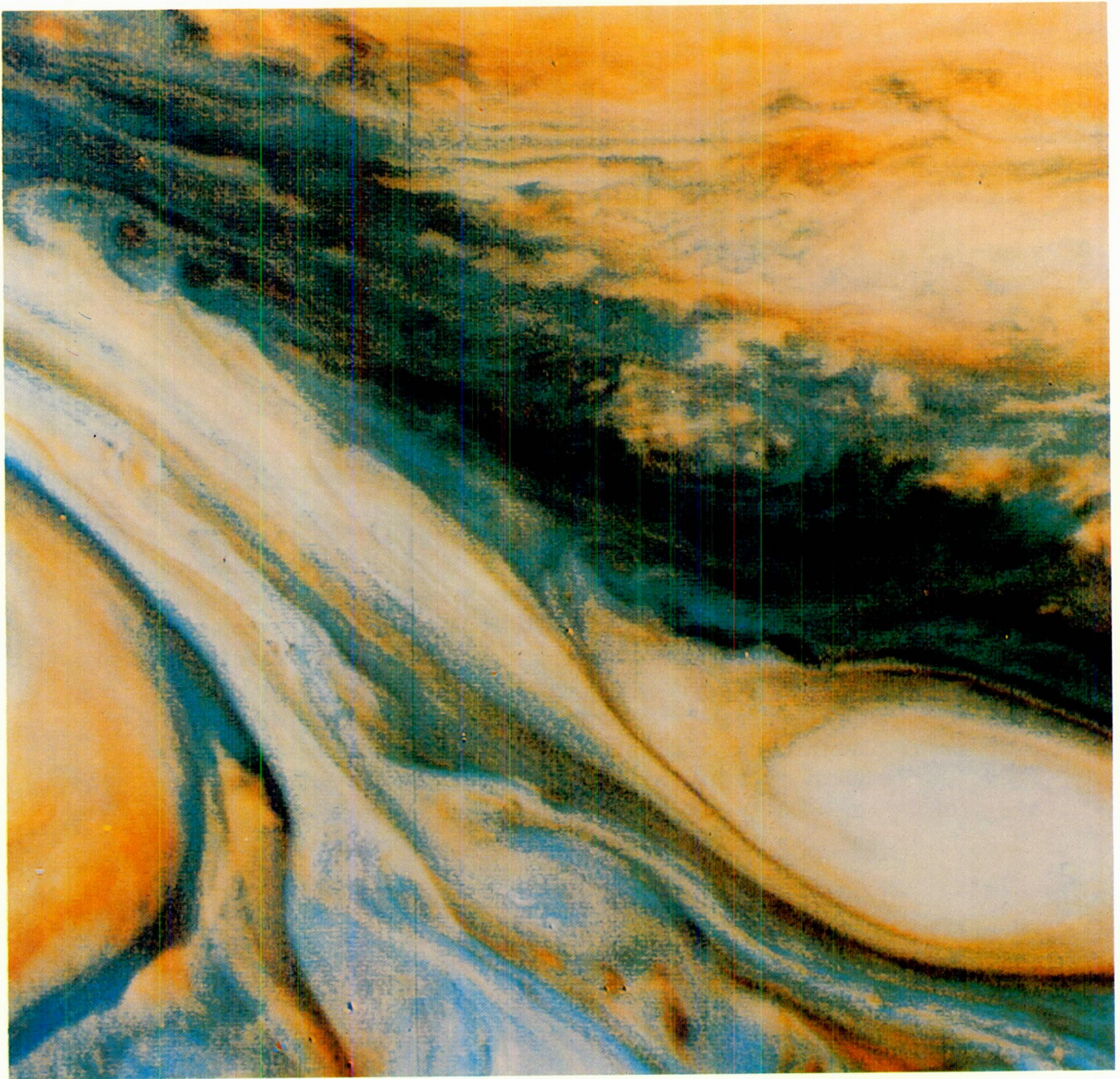
This color view of the Great Red Spot was taken by Voyager 1 on March 4, 1979, at a distance of 1.8 million kilometers (1.1 million miles). Differences in cloud color may indicate relative heights of the cloud layers, but the exact relationship between color and height has not yet been established. The smallest clouds seen in this picture are approximately 30 kilometers (20 miles) across.



This photo was taken at the same time as the preceding picture and shows the region immediately to the right.



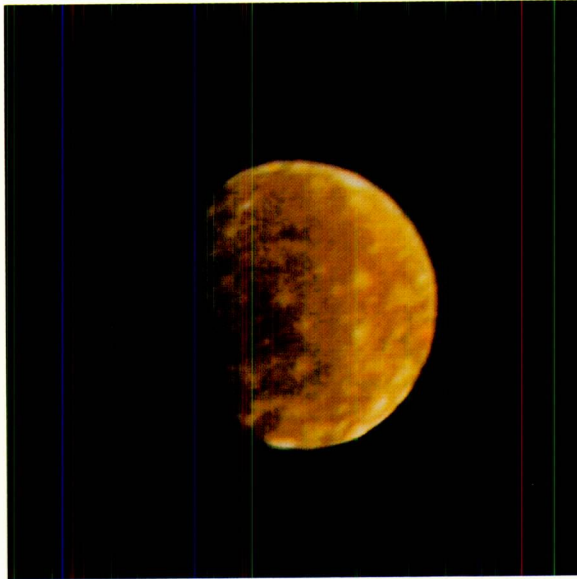
This picture and the one which follows are versions of the preceding two photographs which have been computer-processed to greatly exaggerate the colors.



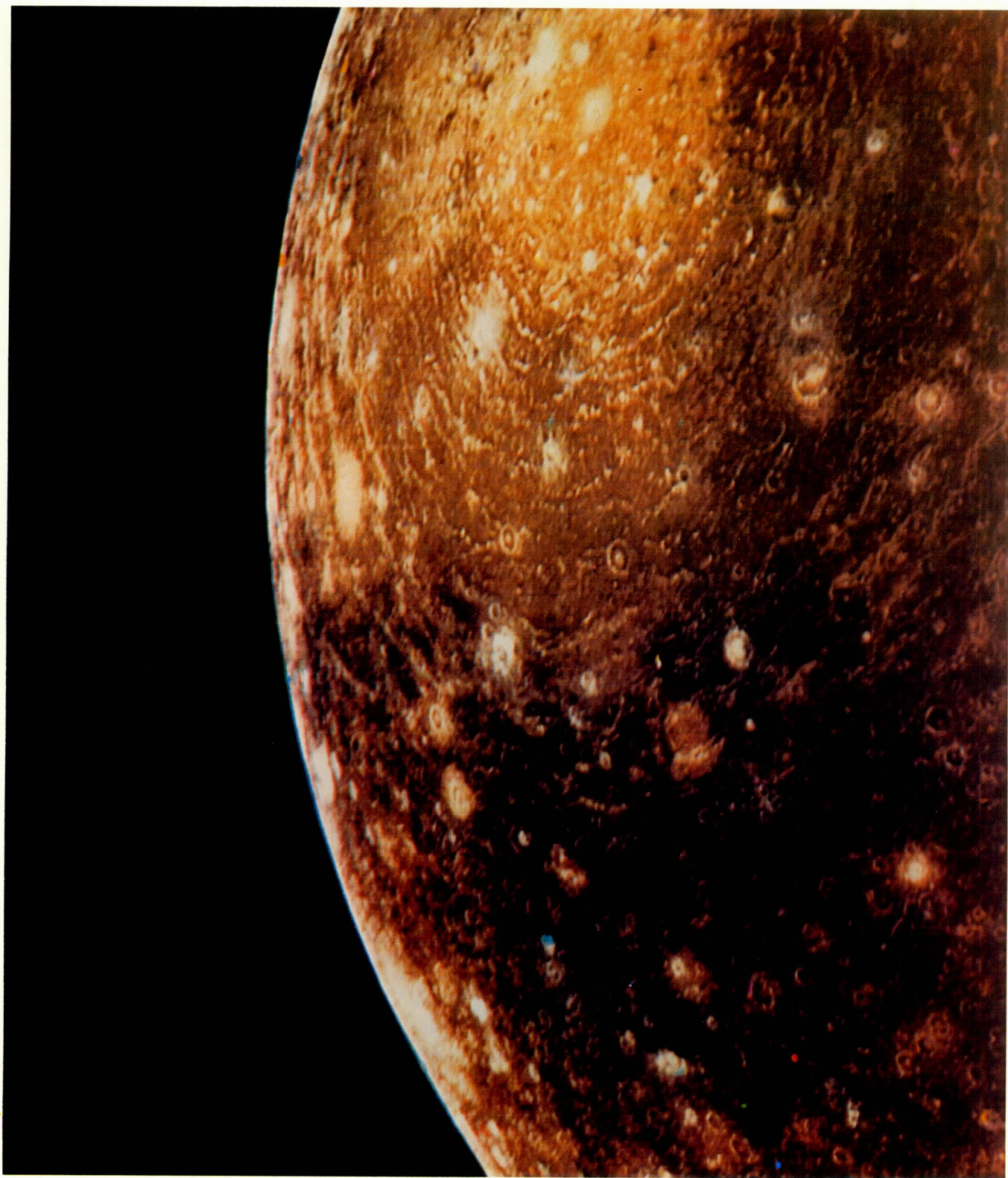
This exaggerated color version does not represent the true hues of the Jovian atmosphere. Instead, it has been computer-processed to enhance subtle variations in both color and brightness, thereby improving the visibility of scene detail.



This photo of Callisto, outermost of Jupiter's four Galilean satellites, was taken on February 26, 1979, by Voyager 1, at a distance of 8 million kilometers (5 million miles). The hemisphere shows a fairly uniform surface dotted with brighter spots that are up to several hundred kilometers across and may be impact craters. Callisto is about the same size as the planet Mercury — about 5000 kilometers (3000 miles) in diameter. Much less massive than Mercury, however, Callisto has a density less than twice that of water. Scientists believe Callisto, therefore, is composed of a mixture of rock and ice (up to about 50 percent by weight). Its surface is darker than those of the other Galilean satellites, but is still about twice as bright as Earth's Moon. This color photo was assembled from three black and white images.

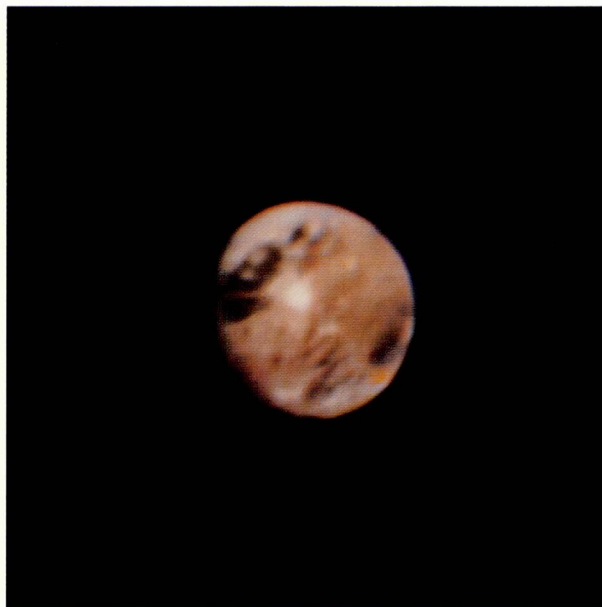


Callisto is the darkest of the Galilean satellites but is still nearly twice as bright as the Earth's Moon. The surface shows a mottled appearance consisting of bright and dark patches. The bright spots remind scientists of rayed or bright haloed craters, similar to those on the Earth's Moon. The Galilean satellites all show the same face to Jupiter, just as the Earth's Moon always shows us the same face. In this photo, taken on February 28, 1979, from a distance of about 7 million kilometers (4.3 million miles), the face of Callisto that always sees Jupiter is pictured. This color photo is assembled from three black-and-white images taken through violet, green, and orange filters.

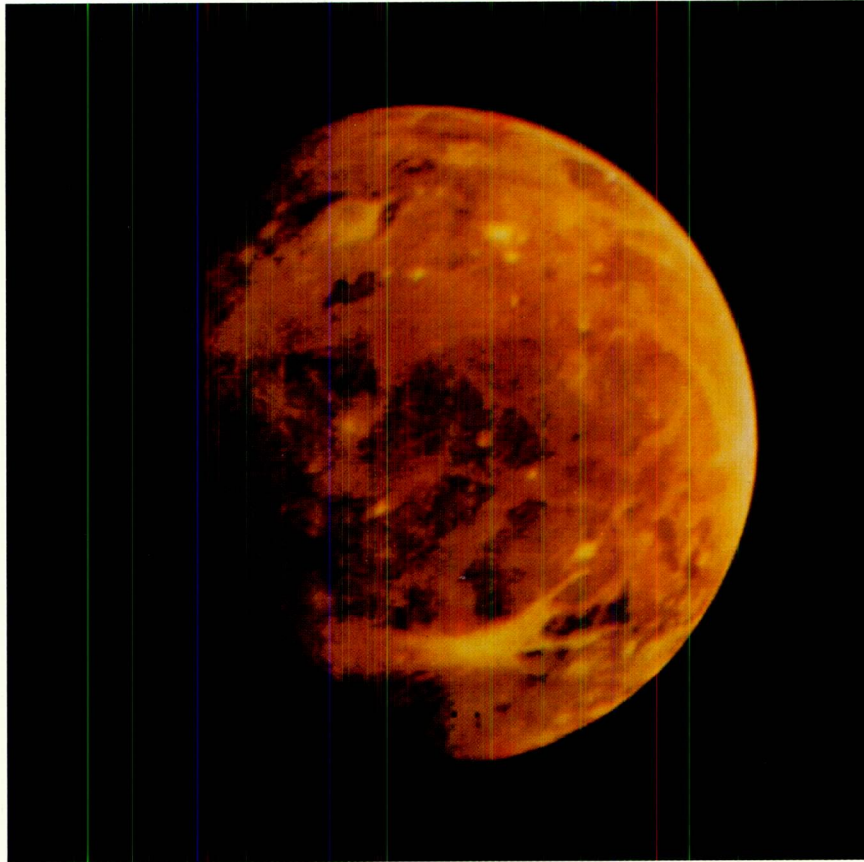


This picture of Callisto was taken on March 6, 1979, during Voyager's approach to Jupiter's outer larger satellite. The spacecraft was 350,000 kilometers (210,000 miles) from Callisto at the time and shows surface features about 7 kilometers (4 miles) across. Smaller than Ganymede (about the size of the planet Mercury), Callisto is apparently composed of a mixture of ice and rock. The darker color of Callisto (about half as reflective as Ganymede but still twice as bright as the Moon) suggests that the upper surface is "dirty ice" or water-rich rock frozen on Callisto's cold surface (approximately 120 K or -243°F at the equator). Far more craters appear on the surface of Callisto than that of Ganymede, leading scientists to believe that Callisto is the oldest of the Galilean satellites. Callisto possibly dates back to final accretional stages of planet formation 4 to 4.5 billion years ago.

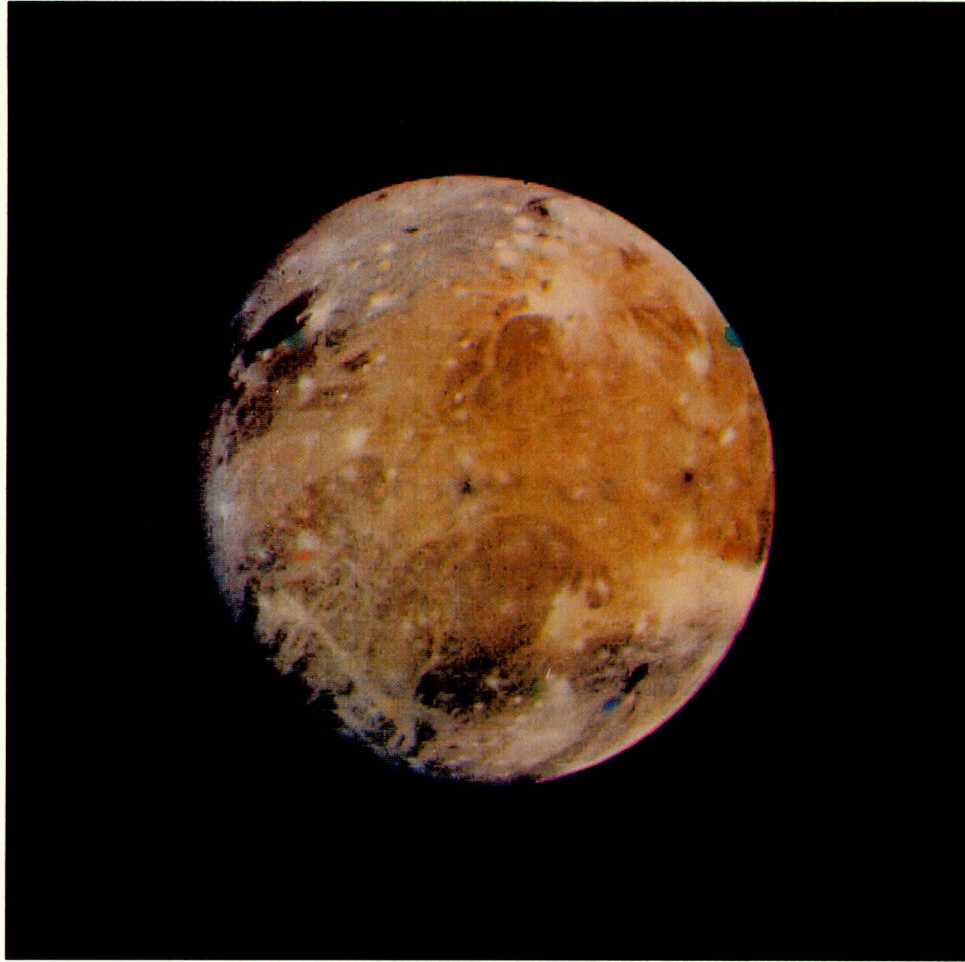
The prominent bullseye feature at the top of this picture is believed to be a large impact basin, similar to Mare Orientale on the Moon and Caloris Basin on Mercury. The bright circular spot is about 600 kilometers (360 miles) across. The outer ring is about 2600 kilometers (1560 miles) across. This is the first recognized basin in the Jovian system and supports the concept of an old surface for Callisto. The lack of high ridges, ring mountains, or a large central depression suggests that the impacting body may have come close to penetrating Callisto's crust. The lack of obvious basins on the side of Ganymede observed by Voyager 1 and the smaller number of craters on Ganymede's surface suggest to scientists that Callisto may have a thicker crust than Ganymede.



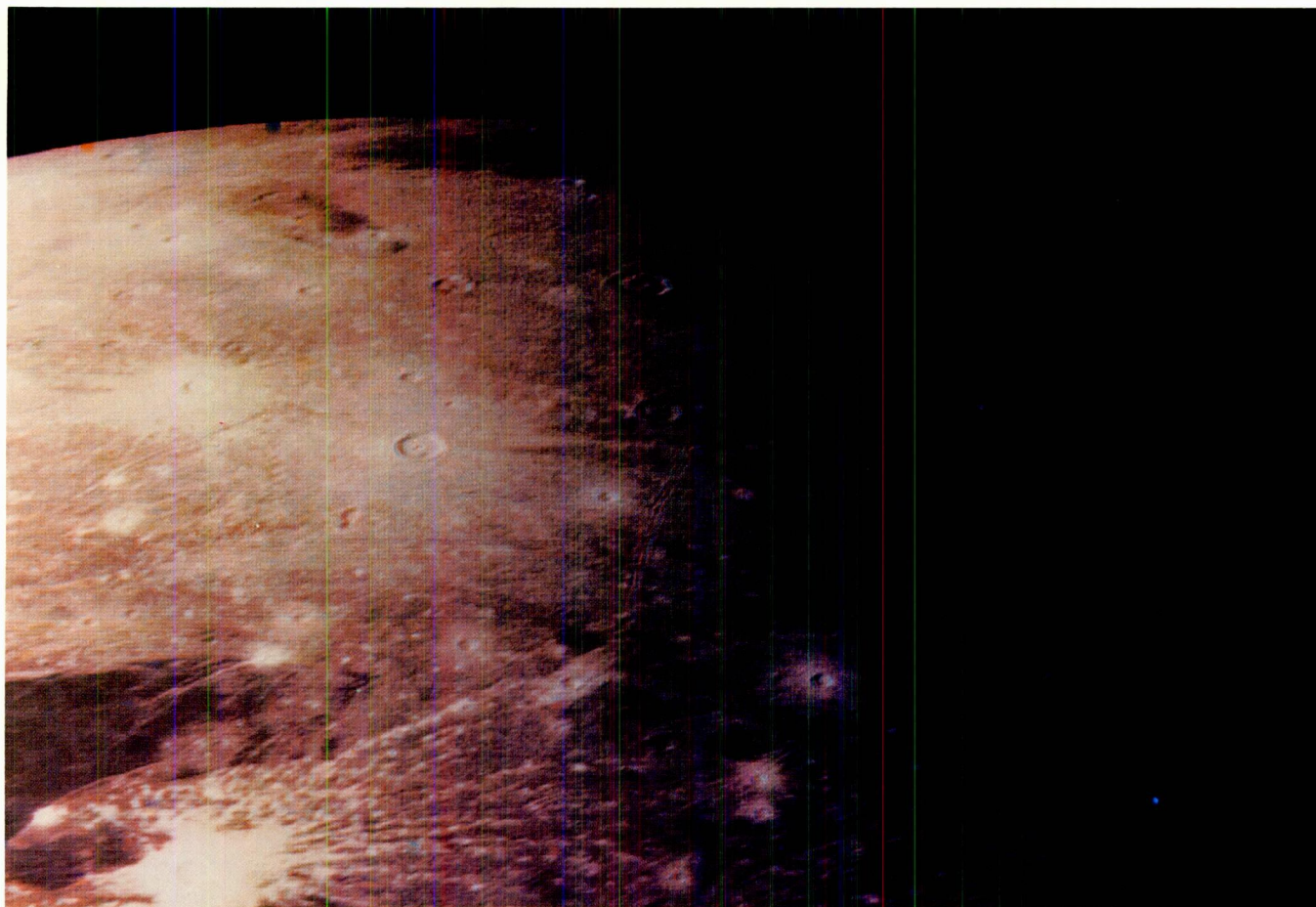
Voyager 1 took this picture of Jupiter's satellite Ganymede from a distance of 8.025 million kilometers (5 million miles) early on the morning of February 26, 1979. Details of the surface are not easily interpreted. The bright spot near the center of the picture is five times brighter than the Moon, and may contain more ice than surrounding areas. The bright pattern around the spot resembles ray craters on the Moon and Mercury; the area may, in fact, be an impact crater that has exposed fresh, underlying ice. Ganymede, the largest of Jupiter's 13 satellites, is slightly larger than the planet Mercury, and has a density about twice that of water. This leads scientists to believe that the satellite is composed of a mixture of rock and ice. Ganymede is about four times brighter than Earth's Moon, and ground-based observations indicate a surface of water frost or ice. This color photo was taken through blue, green, and orange filters.



This color picture of Ganymede was taken on the afternoon of March 2, 1979, from a distance of about 3.4 million kilometers (2.1 million miles). At this resolution the surface shows light and dark markings interspersed with bright spots. The large darkish area near the center of the satellite is crossed by irregular light streaks somewhat similar to rays seen on the Moon. The bright patch in the southern hemisphere is reminiscent of some of the larger rayed craters on the Moon caused by meteorite impacts. Ganymede is slightly larger than the planet Mercury but has a density almost three times less than Mercury. Therefore, Ganymede probably consists in large part of ice.



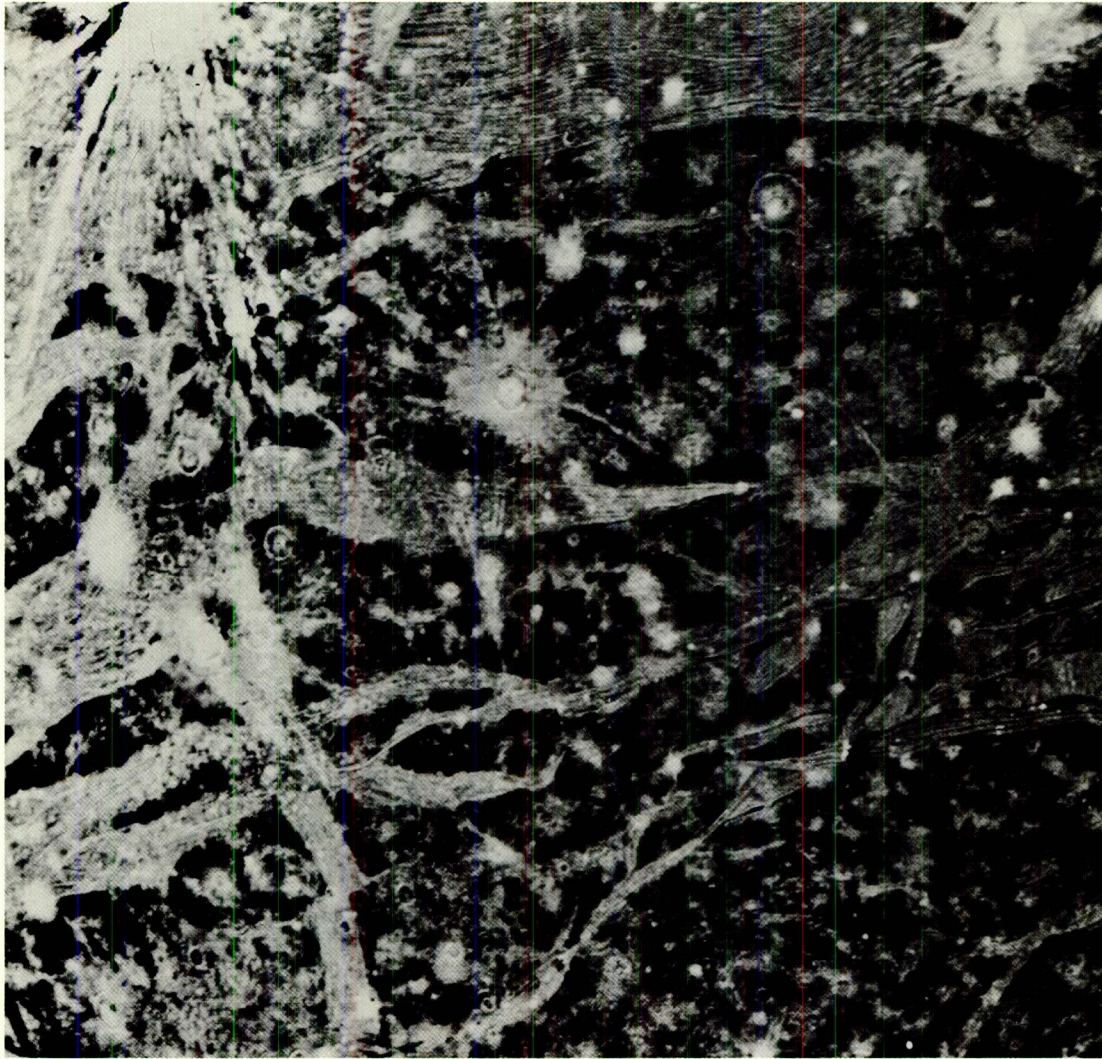
This picture was taken on March 4, 1979, from a distance of 2.6 million kilometers (1.6 million miles). Ganymede is Jupiter's largest satellite with a radius of approximately 2600 kilometers (1600 miles), about 1.5 times that of our Moon. Ganymede has a bulk density of only approximately 2.0 grams per cubic centimeter, almost half that of the Moon. Therefore, Ganymede is probably composed of a mixture of rock and ice. The long, white filaments resemble rays associated with impacts on the lunar surface. The various colors of different regions probably represent differing surface materials.



This color picture was acquired by Voyager 1 during its approach to Ganymede on March 5, 1979, at ranges between about 230,000 to 250,000 kilometers (138,000 to 150,000 miles). The images show detail on the surface with a resolution of 4-1/2 kilometers (2.7 miles). This picture shows the region in the northern hemisphere near the terminator with a variety of impact structures, including both razed and unrazed craters, and the odd, groove-like structures discovered by Voyager in the lighter regions. The most striking features are the bright ray craters which have a distinctly "bluer" color appearing white against the redder background. Ganymede's surface is known to contain large amounts of surface ice, and it appears that these relatively young craters have spread bright fresh ice materials over the surface. Likewise, the lighter color and reflectivity of the grooved areas suggests that here, too, there is cleaner ice. Ray craters with all sizes of ray patterns, ranging from extensive systems of the crater, can be seen in the southern part of the picture, which has rays at least 300-500 kilometers (180-300 miles) long, down to craters which have only faint remnants of bright ejecta patterns. This variation suggests that, as on the Moon, there are processes which act to darken ray material, probably "gardening" by micrometeoroid impact.



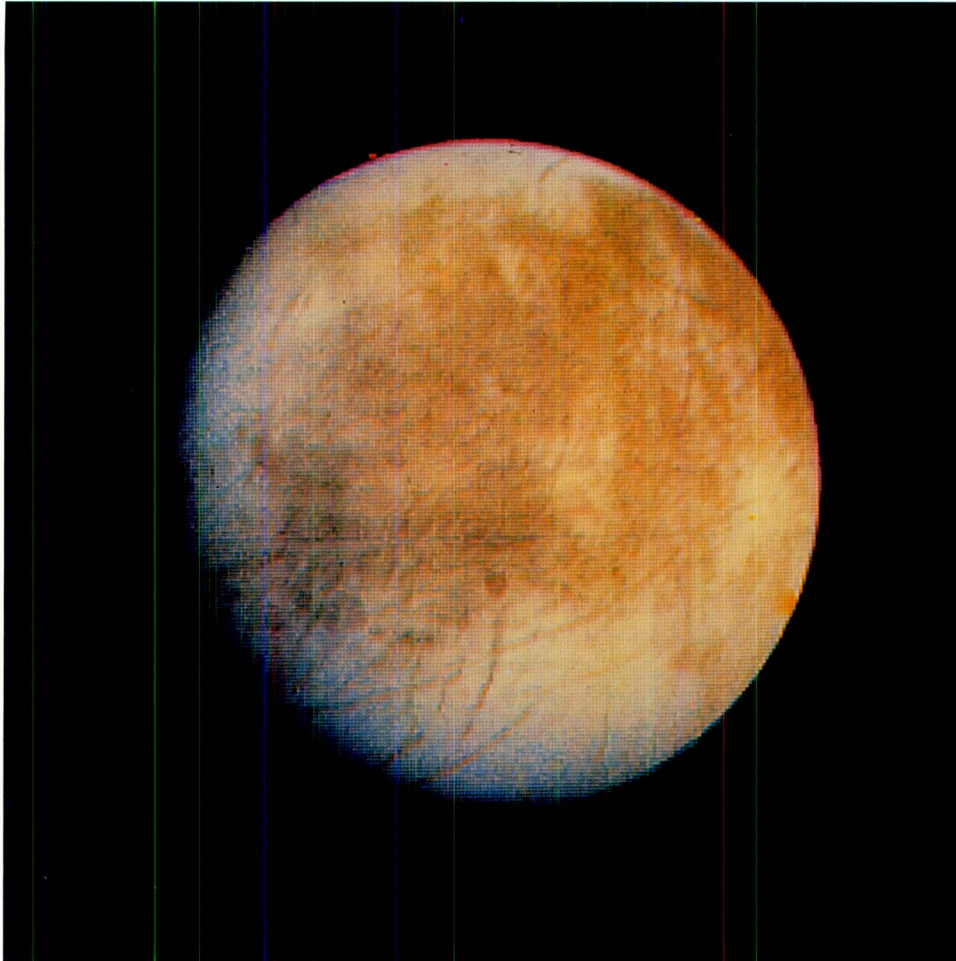
This photograph was taken at approximately the same time and range as the preceding picture. The area seen is just south of the previous view and shows more craters. It also reveals the two distinctive types of terrain found by Voyager: the darker ungrooved regions and the lighter areas which show the grooves or fractures in abundance.



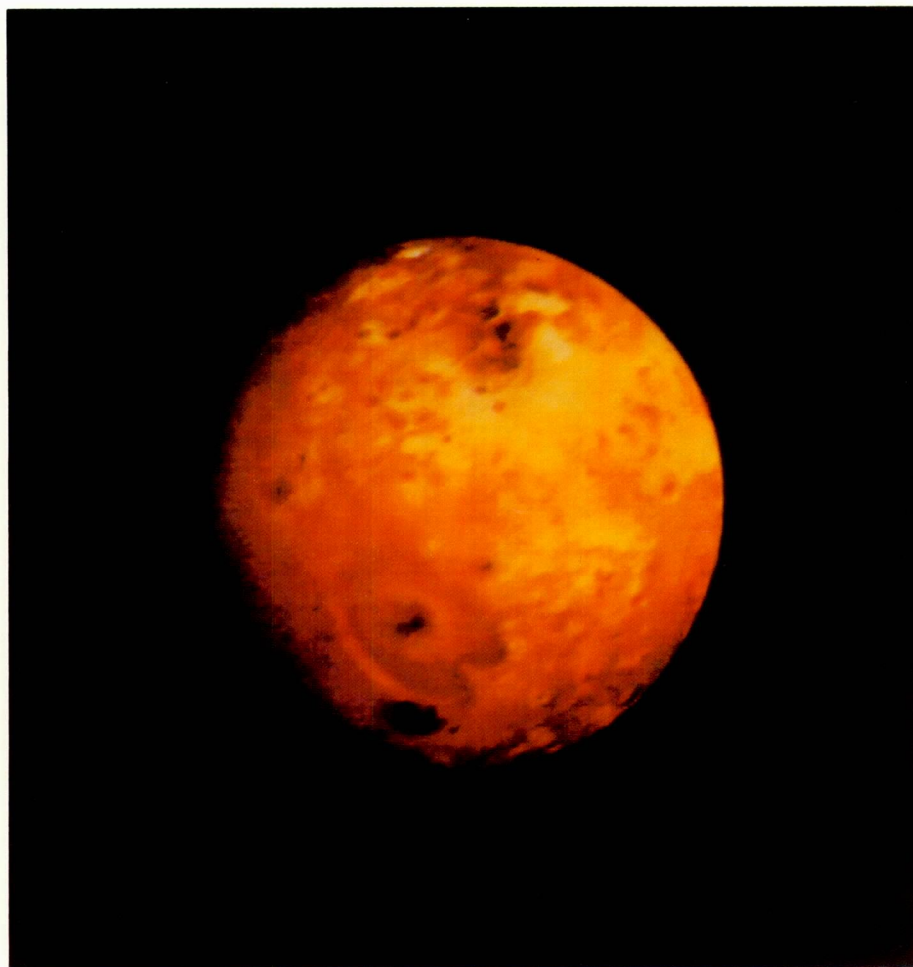
This picture of Ganymede, Jupiter's largest satellite, was taken from a range of 246,000 kilometers (158,400 miles) on March 5, 1979. The center of the picture is at 19° south latitude and 356° longitude, and the height of the frame represents a distance of about 1000 kilometers (600 miles) on the surface. The smallest features seen in this picture are about 2.5 kilometers (1.5 miles) across. The surface displays numerous impact craters, many of which have extensive bright ray systems. The craters lacking ray systems are probably older than those showing rays. Bright bands traverse the surface in various directions, and these bright bands contain an intricate system of alternating linear bright and dark lines that may represent deformation of the crusted ice layer. These lineations are particularly evident near the top of the picture. A bright band trending in a north-south direction in the lower left-hand portion of the picture is offset along a bright line, probably due to faulting. Two light circular areas in the right upper center of the picture may be the scars of ancient impact craters which have had their topographic expansion erased by flowage of the crystal icy material.



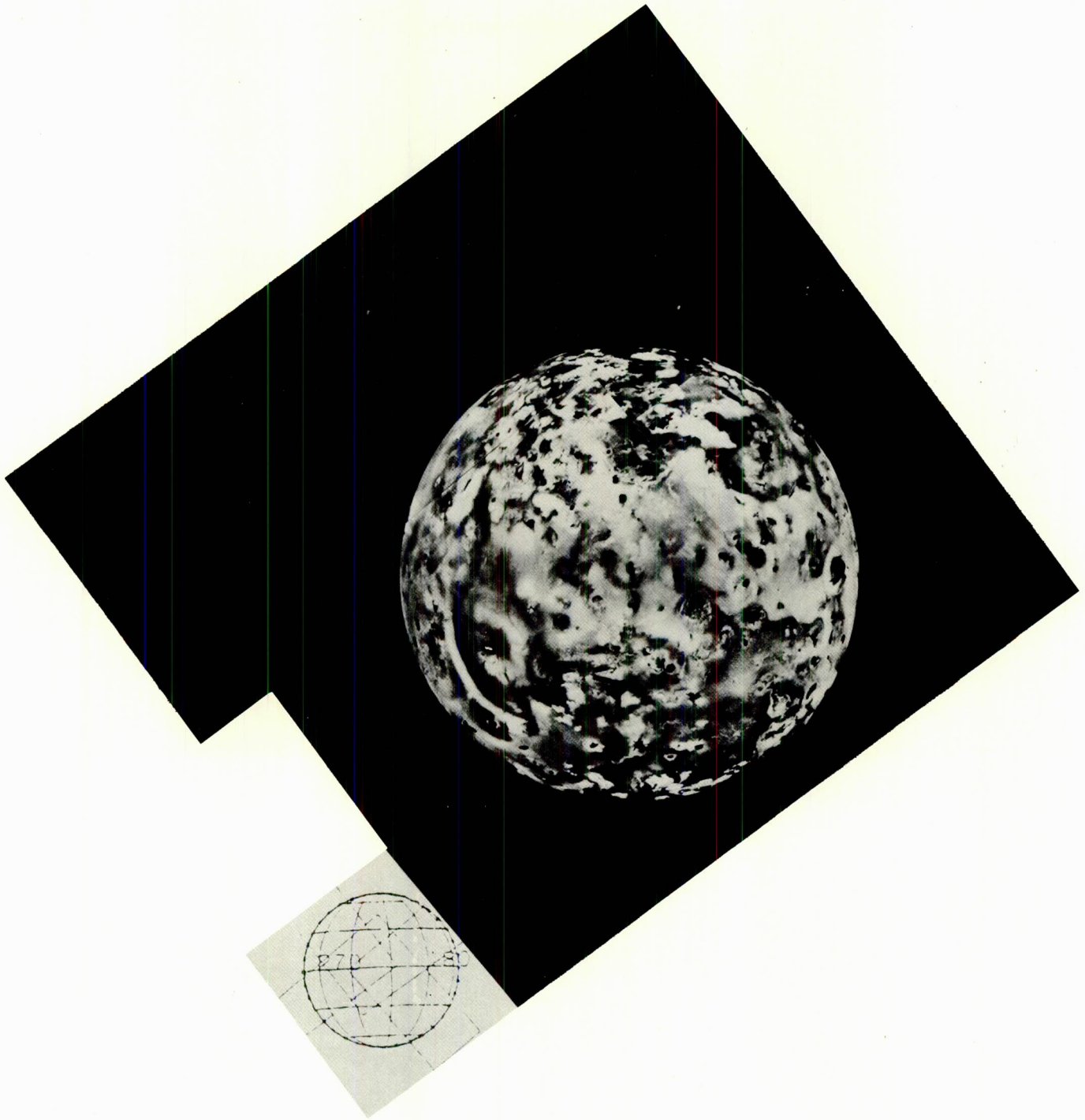
This view of Europa, facing away from Jupiter, shows the smallest Galilean satellite from a range of 2,869,252 kilometers (1.6 million miles) on March 2, 1979. The 170° longitude is at the center of the picture. Irregular dark and bright patches on the surface differ from the patterns on the other satellites of Jupiter and those on the Moon, Mars, and Mercury. Dark intersecting lines may be faults that break the crust. The color composite was made from three black and white images taken through the orange, green, and violet filters.



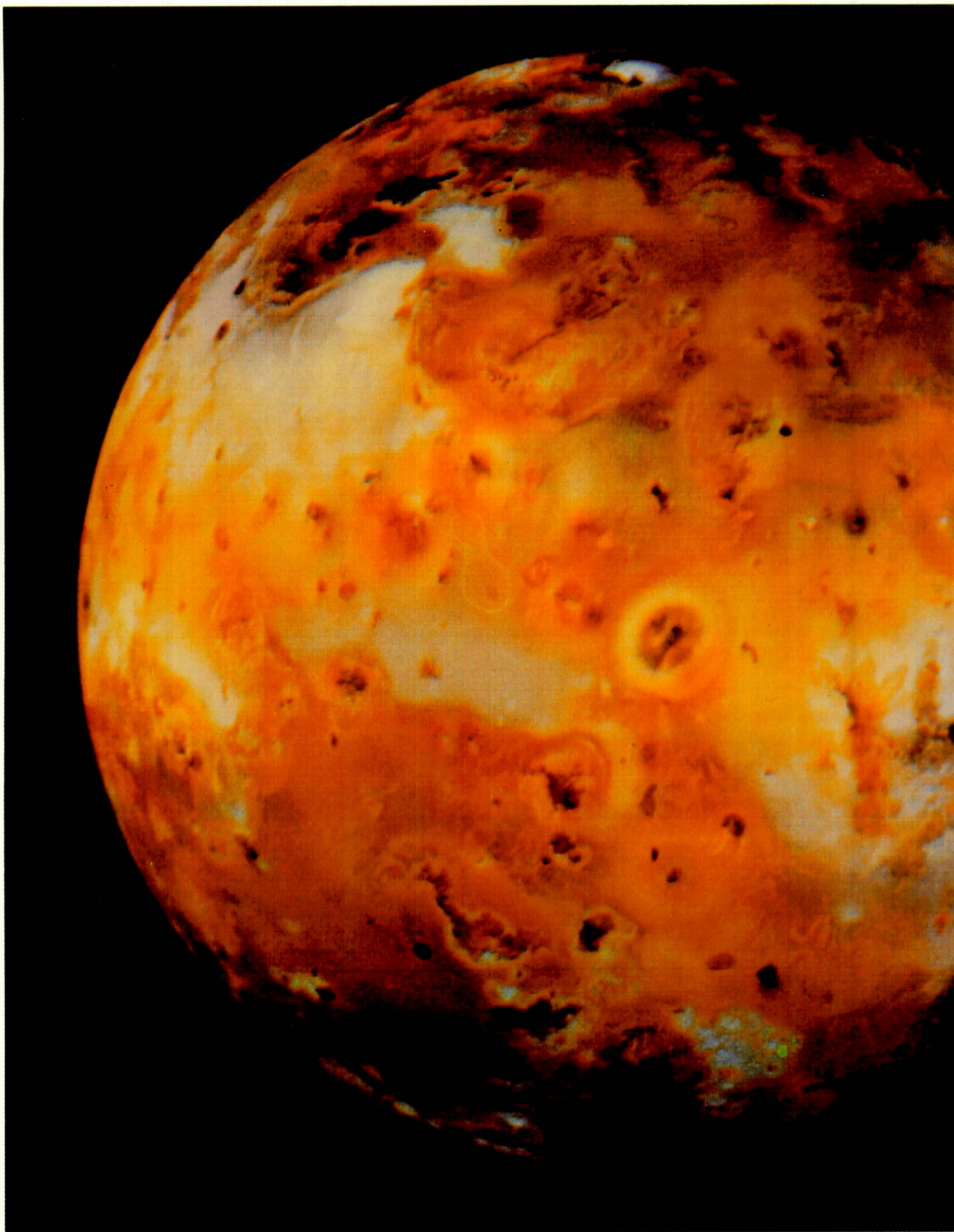
This picture of Europa is centered at about the 300° meridian. The resolution of this picture is about the best that will be obtained by Voyager 1, but the second spacecraft will take much clearer photographs of this satellite in July. Taken in the afternoon of March 4, 1979, from a distance of about 2 million kilometers (1.2 million miles), the bright areas are probably ice deposits, while the dark areas may be the rocky surface or regions with a patchier distribution of ice. The most unusual features are the systems of long linear structures that cross the surface in various directions. Some of these linear structures are over a thousand kilometers (600 miles) long and about 200 or 300 kilometers (120 or 180 miles) wide. They may be fractures or faults which have disrupted the surface.



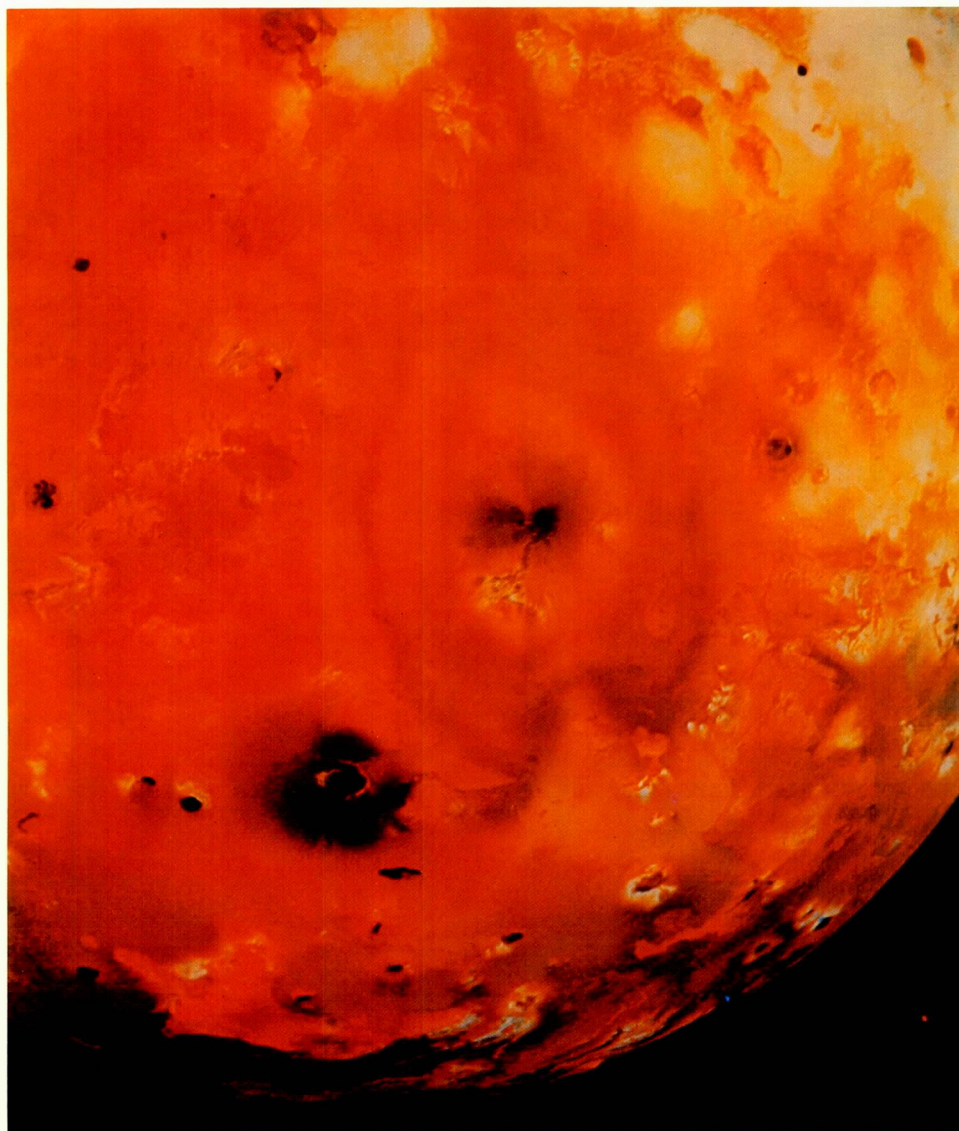
The trailing face of Jupiter's inner satellite Io is shown here with a bright yellow-orange equatorial band (lower left to upper right) separating the darker reddish-brown polar zones. This photo was taken by Voyager 1 on March 3, 1979, from a distance of 2.7 million kilometers (1.7 million miles). The north pole is at the upper left. Characteristic of Io's surface is the profusion of dark spots commonly surrounded by rings of brighter material. The smallest dark spot visible in this view is 30 kilometers (20 miles) wide; the largest, on the left, is about 400 kilometers (250 miles) across. The large heart-shaped feature with a dark spot near its center could be Io's equivalent of an impact basin, such as Mare Orientale on the Moon. Its outer dimensions are about 800 by 1000 kilometers (1280 by 1600 miles). It is located near 15°S by 260°W. The reddish color of Io has been attributed to sulfur in the salts, which are believed by some to make up the surface of Io. Water frost, which occurs on the surfaces of the other Galilean satellites, is absent on Io.



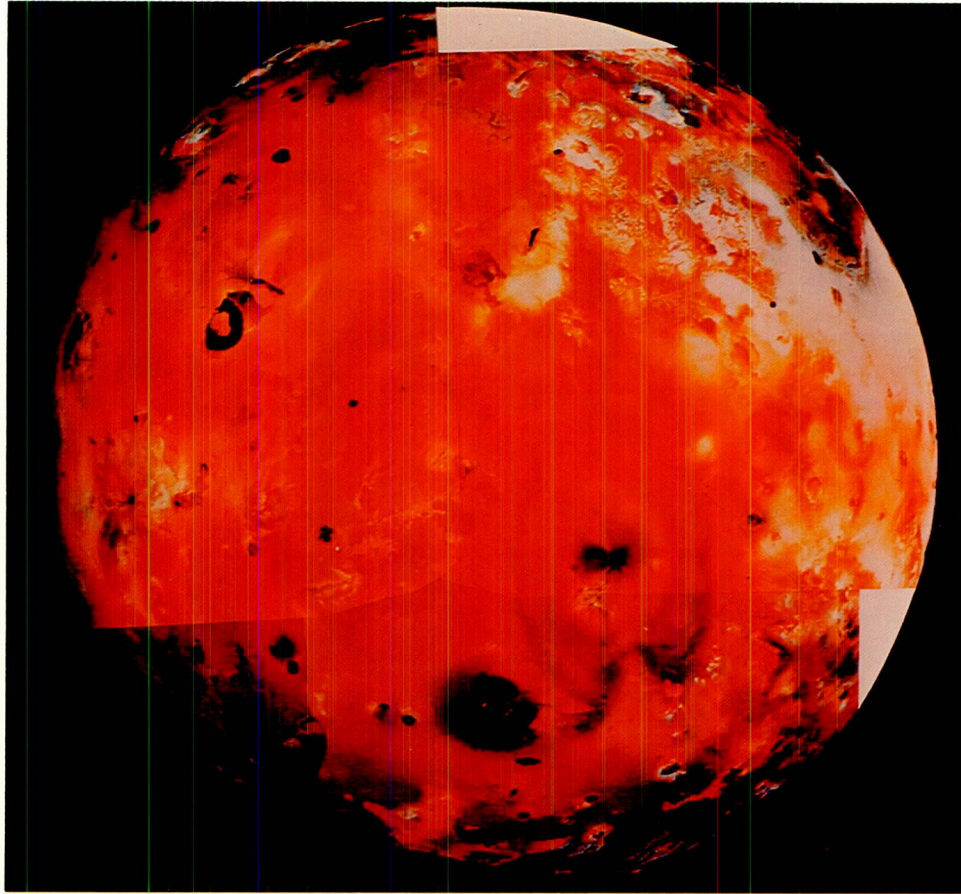
This four-picture mosaic of Jupiter's satellite Io was taken at a range of 496,000 kilometers (307,500 miles) on March 4, 1979. The smallest features visible in this amazing view of Io are 10 kilometers (6 miles) across. The diameter of Io is 3640 kilometers (2184 miles), or about the same size as Earth's Moon (3470 kilometers or 2082 miles).



This view of Io was taken on March 4, 1979, at 7:00 p.m. PST, from a range of 862,200 kilometers (500,000 miles), with the subspacecraft point approximately 140° longitude. Circular features are seen that may be meteorite impact craters or features of internal origin. Irregular depressions indicate that surface modification has taken place. The bright irregular patches appear to be younger deposits masking the surface detail. The high color is believed to consist of mixtures of salts and sulfur, brought to the surface by volcanic activity and other processes. This surface is thought to be the source of material for the clouds of neutral and ionized atoms around Io's orbit, observed by ground-based telescopes.



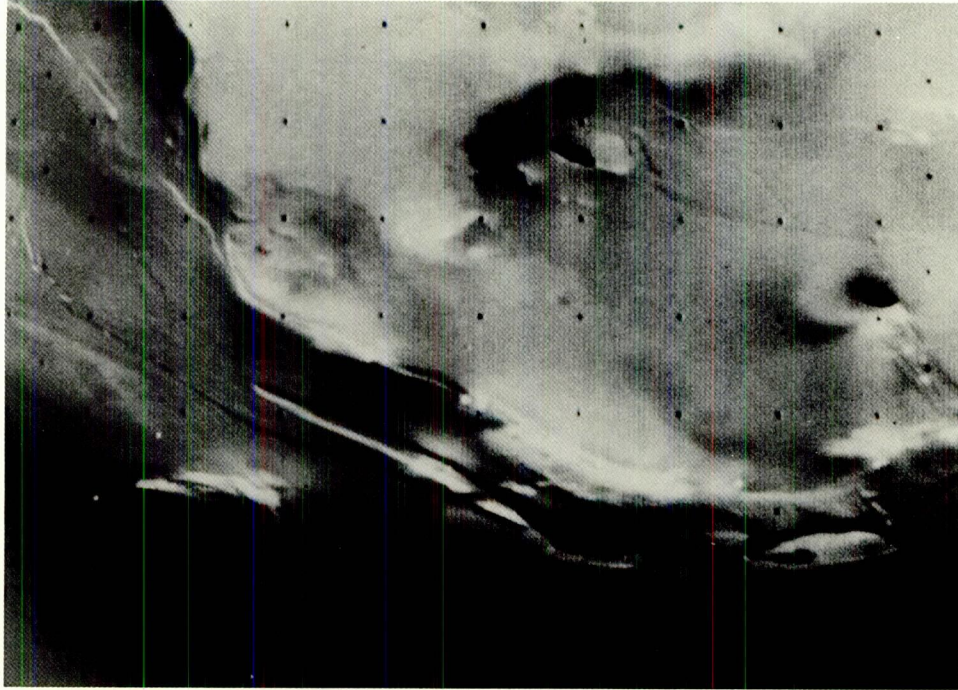
This striking picture of Io was taken on the morning of March 5, 1979, at a range of 377,000 kilometers (226,200 miles). The smallest features visible are about 10 kilometers (6 miles) across. The reddish, white, and black areas are probably surface deposits, perhaps consisting of mixtures of salts, sulfur, and sublimate deposits — possibly associated with volcanic origin, as are many of the black spots in these pictures. The lack of impact craters on Io suggests that the surface is relatively young compared to the other Galilean satellites and some of the terrestrial bodies, such as Mercury, and the Moon.



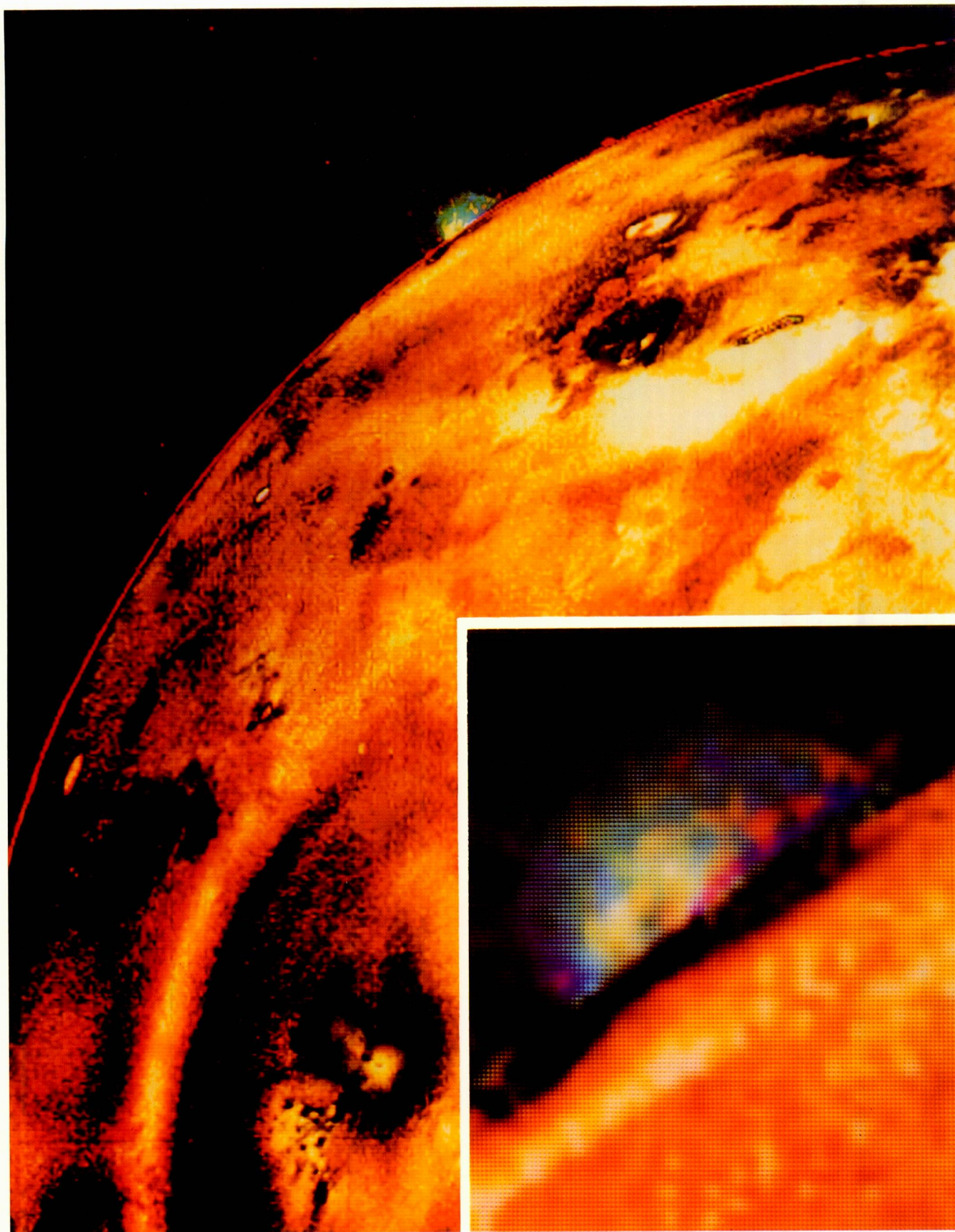
This four-picture color mosaic of Io was taken on March 4, 1979, at 11:00 p.m. PST, from a range of 376,951 kilometers (226,170 miles) and shows features about 8 kilometers (5 miles) in dimension. The picture was constructed from black and white pictures taken in violet and orange light and shows a somewhat exaggerated color. There are no obvious impact features identifiable in this hemisphere at this resolution, suggesting to scientists that Io's surface is quite young. The numerous features visible in this picture are being studied in higher resolution pictures taken during Voyager 1's encounter with Jupiter's minor Galilean moon. Many of these features are believed to be of internal, possibly volcanic, origin. The highly colored surface is believed to consist of mixtures of salts and sulfur, possibly brought to the surface by volcanic activity. This surface is thought to be the source of material for the clouds of neutral and ionized atoms around Io's orbit observed by ground-based telescopes and also the doubly ionized sulfur torus discovered by Voyager 1's ultraviolet spectrometer experiment.



This picture of Io was taken on the morning of March 5, 1979, at a range of 128,500 kilometers (77,100 miles). Centered at 8° south latitude and 317° longitude, the width of the picture is about 1000 kilometers (600 miles). The diffuse reddish and orangish colorations are probably surface deposits of sulfur compounds, salts, and possible other volcanic sublimates. The dark spot with the irregular radiating pattern near the bottom of the picture may be a volcanic crater with radiating lava flows.

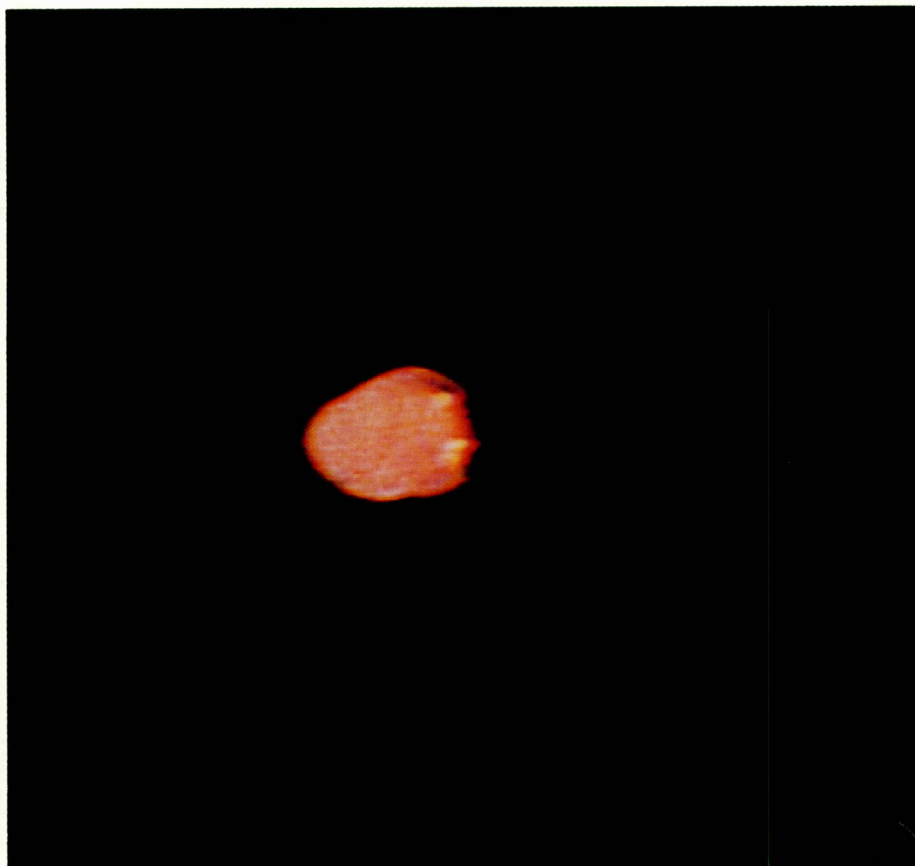


This picture of Io was taken on the morning of March 5, 1979, at a range of about 92,000 kilometers (55,000 miles). The view of the terminator region is centered at 60° south latitude and 276° longitude. The Sun is shining from lower-left to upper-right. Shadows cast by cliffs are clearly visible near the terminator. The long valley which parallels the terminator is about 300 kilometers (180 miles) long and 50 kilometers (30 miles) wide. It may be a fault trough due to crustal deformation. Other cliffs which parallel the trough may also be faults. The large bright patch in the lower left portion of the picture and the two black spots are probably some type of surface deposits.

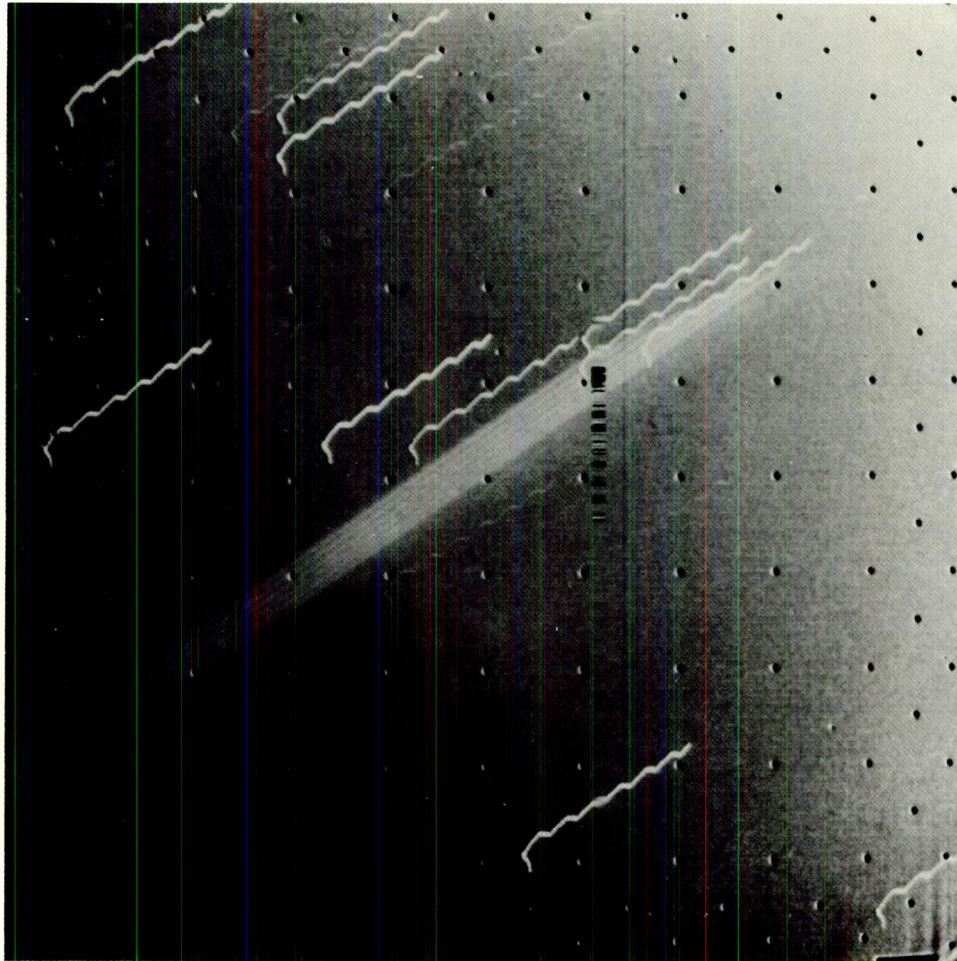


This image of Io was acquired on March 4 about 11 hours before closest approach to the satellite. The distance to Io was about 490,000 kilometers (294,000 miles). An enormous volcanic explosion can be seen silhouetted against dark space over Io's bright limb. The brightness of the extremely faint plume (see inset) has been increased by the computer, whereas the relative color of the plume (greenish white) has been preserved. In this picture, solid material has been thrown up to an altitude of about 160 kilometers (100 miles), which requires an ejection velocity from the volcanic vent of about 1920 kilometers (1200 miles) per hour, material reaching the crest of the plume in several minutes. The vent area is a complex circular structure consisting of a bright ring about 300 kilometers (180 miles) in diameter and a central region of irregular dark and light patterns. This is the first currently active vulcanism identified on solar system bodies other than planet Earth. Io appears to be far more active volcanically than Earth.

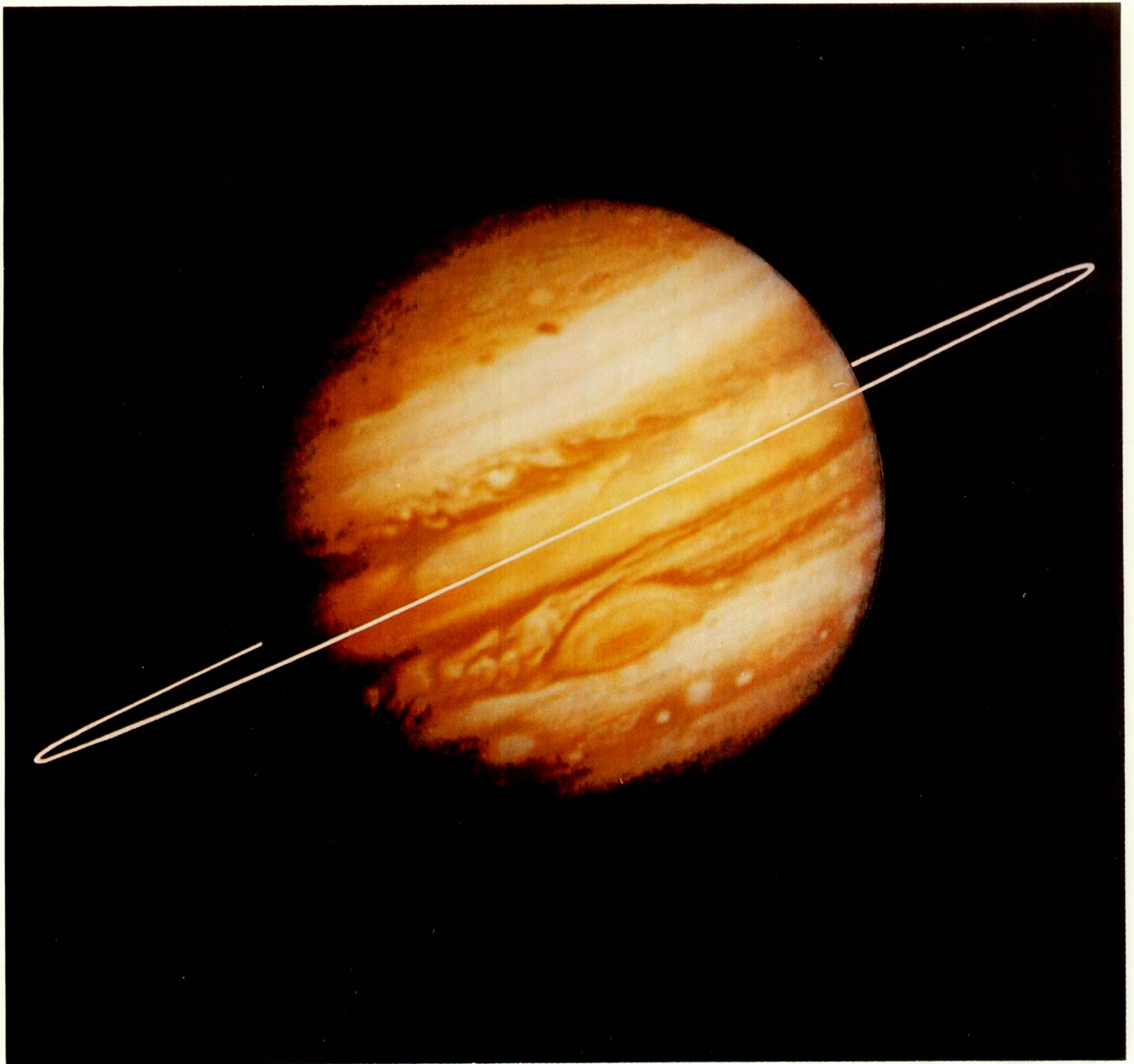
Volcanic explosions similar to this occur on Earth when magmatic gases expand explosively as material is vented. On Earth, water vapor is the major gas driving the explosion. Because Io is thought to be extremely dry, scientists are searching for other gases to explain the explosion.



Tiny, red Amalthea, Jupiter's innermost satellite, whizzes around the planet every 12 hours, only 1.55 Jupiter radii from the cloud tops. In this view taken from a range of 425,000 kilometers (255,000 miles) on March 4, the satellite appears about 130 kilometers (80 miles) high by 170 kilometers (102 miles) wide. Since the phase angle is $29\frac{1}{4}^\circ$, part of the longer dimension is not illuminated. The terminator is on the right, north is at the top, and Jupiter is to the left. The reflectivity of the surface is less than 10 percent, making Amalthea much darker than the Galilean satellites. Amalthea's irregular shape probably results from a long history of impact cratering. Some of the indentations near the bottom and at the upper right may be marginally resolved craters. The effective resolution of this image is about 8 kilometers (5 miles). An important question is whether the red color is characteristic of the bulk of Amalthea, or whether, as is more likely, it results from a coating or alteration of the surface material. This irregular satellite probably keeps its long axis pointed toward Jupiter in its motion around the planet so that the spin period around its own axis equals its period of revolution around Jupiter (12 hours). Unlike the four large Galilean satellites which have been known since 1610, Amalthea was discovered only 87 years ago, in 1892, by the American astronomer Edmund Emerson Barnard at Lick Observatory.



First evidence of a ring around the planet Jupiter is seen in this photograph taken on March 4, 1979. The multiple exposure of the extremely thin faint ring appears as a broad light band crossing the center of the picture. The edge of the ring is 1,212,000 kilometers (727,200 miles) from the spacecraft and 57,000 kilometers (34,200 miles) from the visible cloud deck of Jupiter. The background stars look like broken hairpins because of spacecraft motion during the 11-minute, 12-second exposure. The wavy motion of the star trails is due to the ultra-slow natural oscillation of the spacecraft (with a period of 78 seconds). The black dots are geometric calibration points in the camera. The ring thickness is estimated to be 30 kilometers (20 miles) or less. The photograph was part of a sequence planned to search for such rings in Jupiter's equatorial plane. The ring has been invisible from Earth because of its thinness and its transparency when viewed at any angle except straight on.



This picture indicates the approximate outer diameter of the newly found ring of Jupiter. The radial width of the ring is unknown because the Voyager 1 image was necessarily taken precisely when the spacecraft was crossing the ring's plane, providing an edge-on view in which the ring appeared as a line. This illustration combines an artist's ellipse with an early Voyager 1 Jupiter photograph.

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